Bucket Foundations under Axial Loading

Test Data Series 13.02.XX, 13.03.XX and 14.02.XX

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by

E. Vaitkunaite

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Contents

CHAPTER 1
List of Symbols

Greek Symbols

γ	Total soil unit weight
γ'	Effective soil unit weight
σ	Standard deviation

Latin Symbols

D	Bucket model diameter
D_R	Relative soil density
F	Load
F_{cyc}	Cyclic load amplitude
F_{mean}	Mean cyclic load
F_P	Preload during installation
F_{Pc}	Peak post-cyclic tensile load
F_T	Peak tensile load
N	Cycle number
PP	Pore pressure transducer
d	Skirt length
d_{inst}	Installed skirt length
f_s	Data sampling frequency
f	Loading frequency
p_m	Membrane pressure

p_t	Tank pressure
v	Tensile load velocity (Pull-out rate)
t	Skirt thickness
w_{cyc}	Displacement during cyclic load
w_T	Displacement at peak tensile load
w_{Pc}	Displacement at peak post-cyclic tensile load

CHAPTER 2
Test Series 14.02.XX Overview

Series 14.02.XX present tensile loading tests on a bucket foundation model performed with different pull-out rates. This chapter provides the data of tests performed in the pressure tank. Bucket model dimensions were: 0.50 m in diameter D, 0.25 m in skirt length d and 2 mm in skirt thickness t. Figure 2.3 shows the positions of the laboratory CPT samplings. Sørensen and Ibsen (2012) have shortly described the test set-up. Hedegaard and Borup (1993), Ibsen and Boedker (1994) have studied the Aalborg University sand No.1. properties.

Table 2.1: Test series 14.02.XX summary.

p_t, [kPa]	Test No.	Loading			Installation		D_R, [%]	γ', [kN/m^3]
		F_T, [kN]	w_T, [mm]	v, [mm/s]	F_P, [kN]	d_{inst}, [mm]		
163	14.02.01	-3.91	-0.46	0.05	-	-	75	9.1
177	14.02.02	-2.03	-0.81	0.10	36.2	244.2	88	9.7
197	14.02.03	-2.74	-2.66	0.25	33.2	240.0	92	9.9
200	14.02.04	-8.02	-3.61	1	37.6	242.0	88	9.7
201	14.02.05	-30.79	-16.01	10	43.7	241.5	90	9.8
199	14.02.06	-36.94	-22.30	17.80	31.9	242.3	88	9.7
200	14.02.07	-44.07	-14.73	21.70	33.0	236.2	83	9.5
200	14.02.08	-48.84	-14.29	27.20	31.5	239.0	85	9.6
200	14.02.09	-65.36	-48.78	46.71	31.5	236.4	83	9.5
200	14.02.10	-	-	0.05	32.3	246.6	86	9.6
200	14.02.11	-4.08	-0.65	0.10	31.4	240.7	86	9.6
200	14.02.12	-2.67	-0.70	0.05	32.0	239.2	85	9.6
200	14.02.13	-71.65	-60.48	98.30	31.0	239.3	82	9.5
200	14.02.14	-75.17	-68.18	152.30	37.0	236.0	84	9.5
0	14.02.15	(0)	(0)	0.01	31.0	240.5	79	9.3

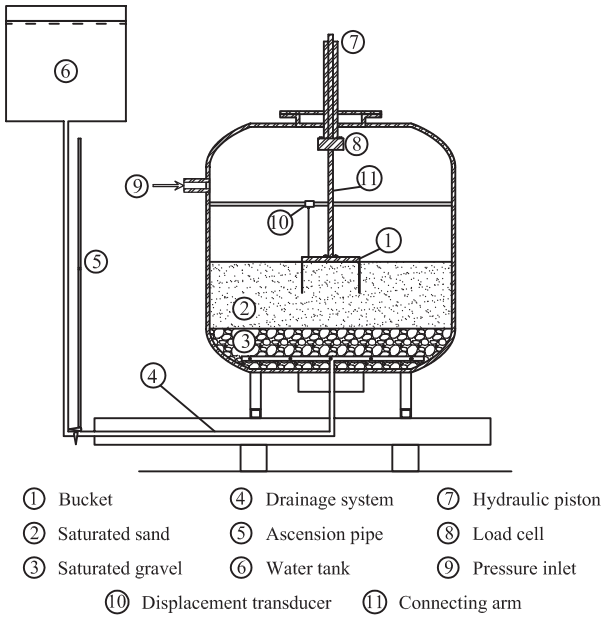

Figure 2.1: Test set-up for testing program 14.02.XX.

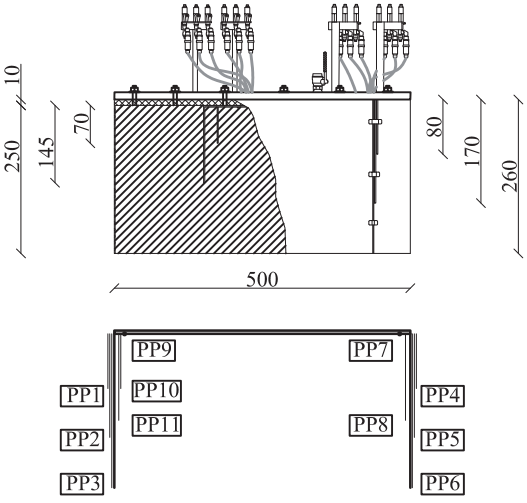

Figure 2.2: Bucket foundation model for testing program 14.02.XX.

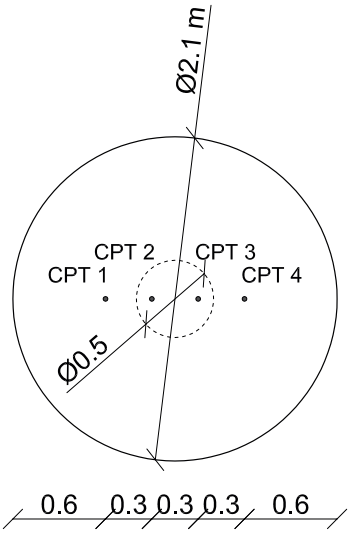

Figure 2.3: CPT positions.

2.1 Test 14.02.01

Soil properties			Loading			Installation		
D_R	[%]	75.2	f_s	[Hz]	5	F_P	[kN]	-
σ of D_R	[%]	2.6	F_T	[kN]	-3.91	d_{inst}	[mm]	-
γ	[kN/m^3]	19.1	w_T	[mm]	-0.46	Tank pressure		
γ'	[kN/m^3]	9.1	v	[mm/s]	0.05	p_t	[kPa]	163

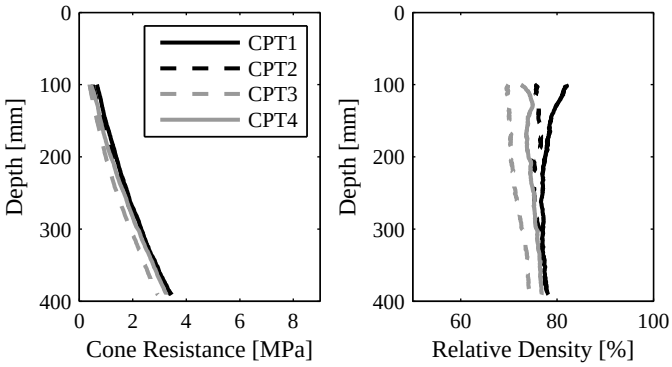

Figure 2.4: CPT testing 14.02.01.

Figure 2.5: Installation 14.02.01.

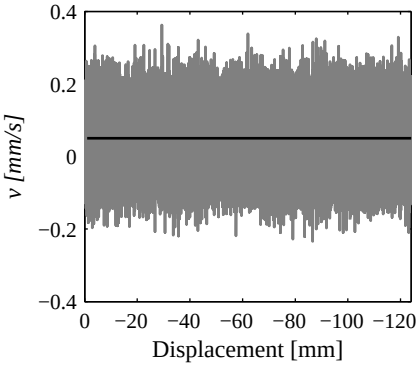

Figure 2.6: Pull-out velocity 14.02.01.

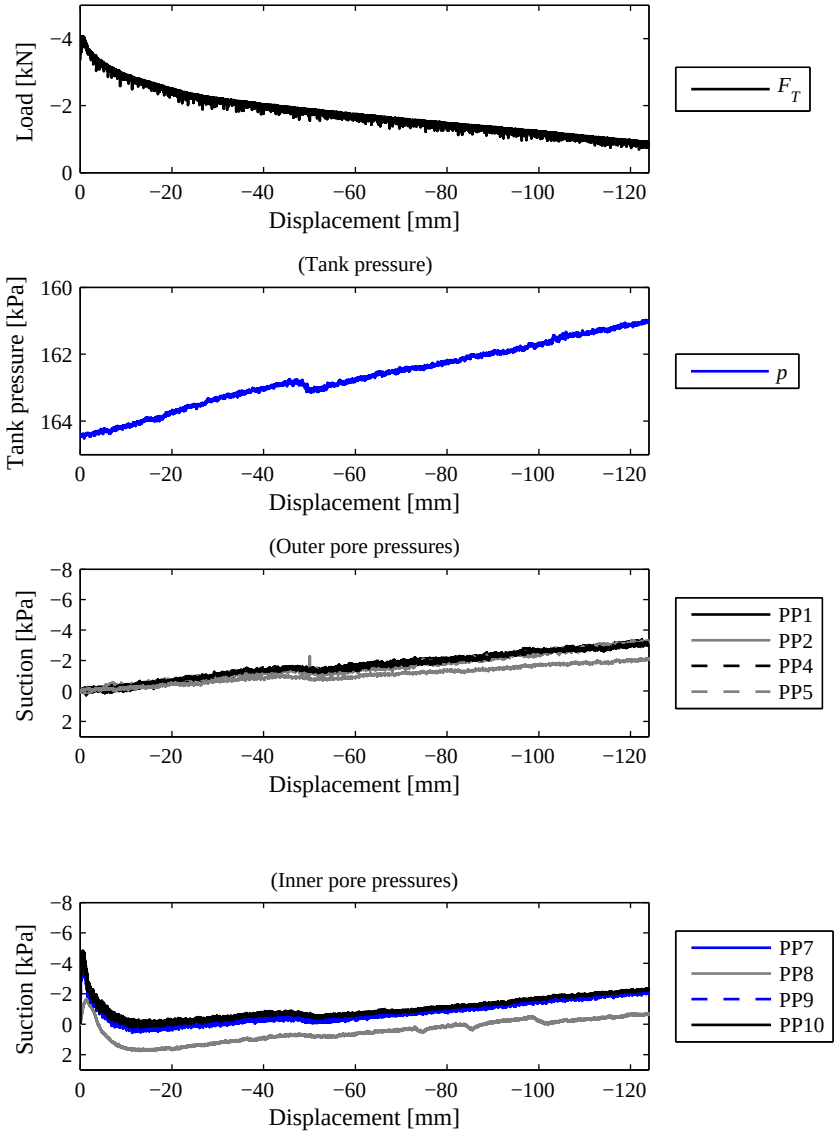

Figure 2.7: Loading 14.02.01.

Comments:
The first test with very disturbed sand from previous testing. Load cell was not zeroed before the installation. Tank pressure was unstable due to pressure leakage from the tank. The test is discharged from any analysis. Pressure transducers PP3, PP6, PP11 did not function. Improvements to the test set-up followed: tightening of the pressure tank, tightening and calibrating pressure transducers.

2.2 Test 14.02.02

Soil properties			Loading			Installation		
D_R	[%]	87.6	f_s	[Hz]	5	F_P	[kN]	36.2
σ of D_R	[%]	5.7	F_T	[kN]	-2.03	d_{inst}	[mm]	244.2
γ	[kN/m^3]	19.7	w_T	[mm]	-0.81	Tank pressure		
γ'	[kN/m^3]	9.7	v	[mm/s]	0.10	p_t	[kPa]	177

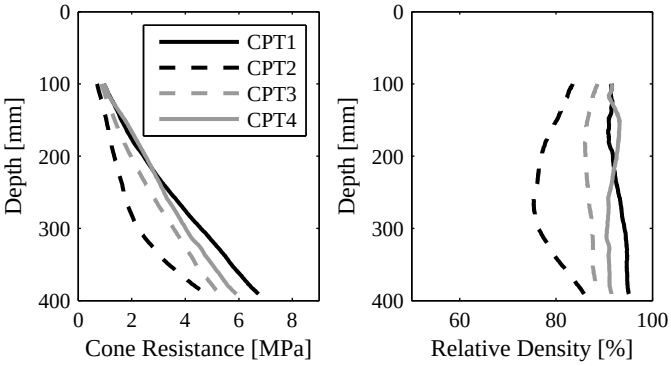

Figure 2.8: CPT testing 14.02.02.

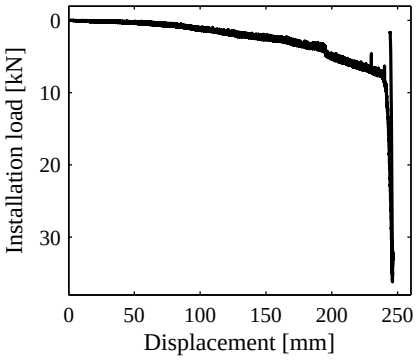

Figure 2.9: Installation 14.02.02.

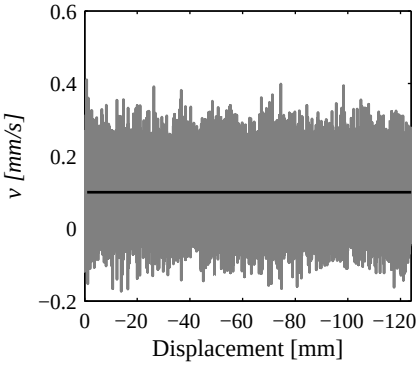

Figure 2.10: Pull-out velocity 14.02.02.

Comments:
Tank pressure did not reach the wanted value (200 kPa). Pressure transducer PP3 did not function.

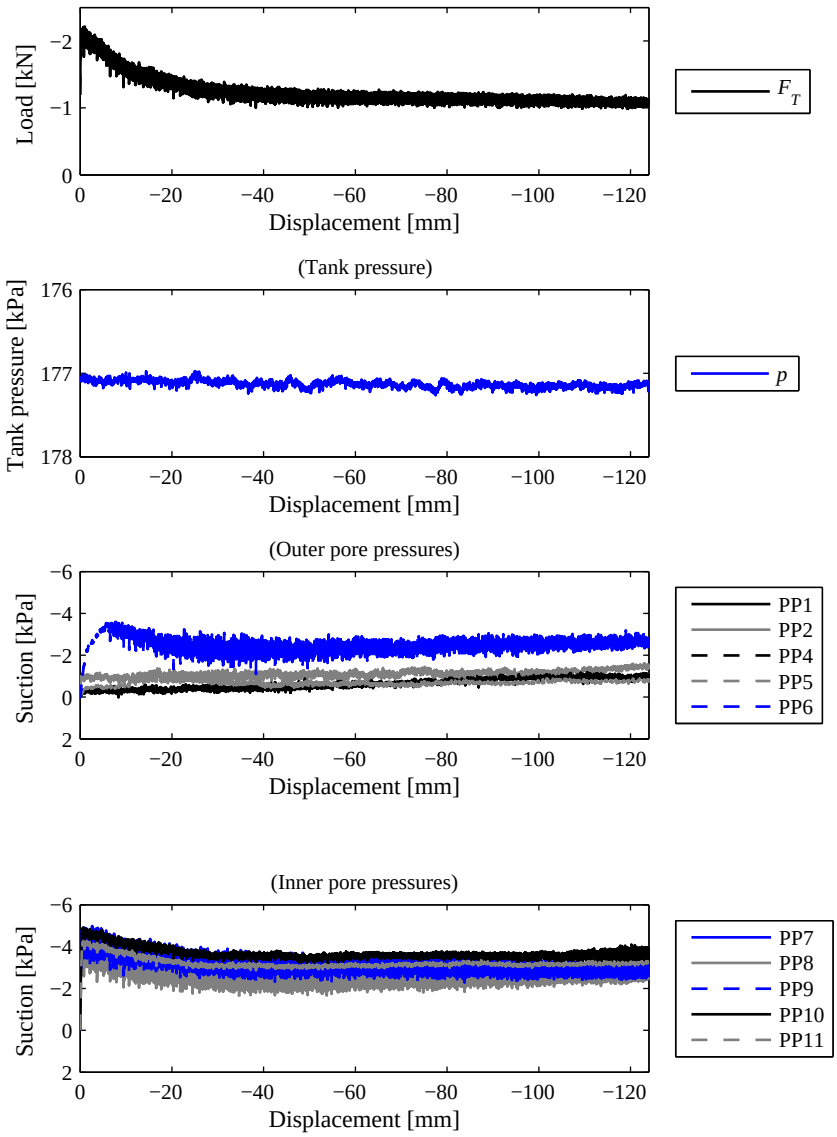

Figure 2.11: Loading 14.02.02.

2.3 Test 14.02.03

Soil properties			Loading			Installation		
D_R	[%]	91.6	f_s	[Hz]	5	F_P	[kN]	33.2
σ of D_R	[%]	3.1	F_T	[kN]	-2.74	d_{inst}	[mm]	240.0
γ	[kN/m^3]	19.9	w_T	[mm]	-2.66	Tank pressure		
γ'	[kN/m^3]	9.9	v	[mm/s]	0.25	p_t	[kPa]	197

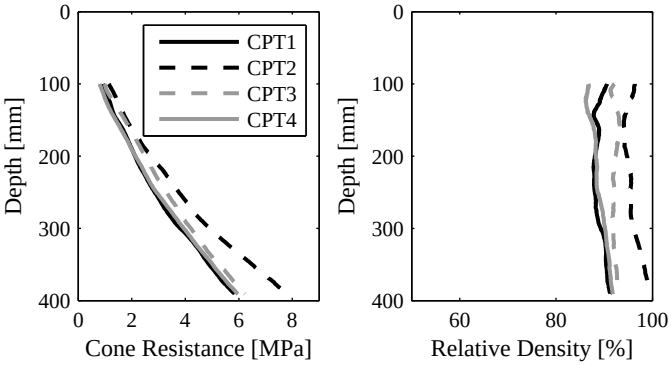

Figure 2.12: CPT testing 14.02.03.

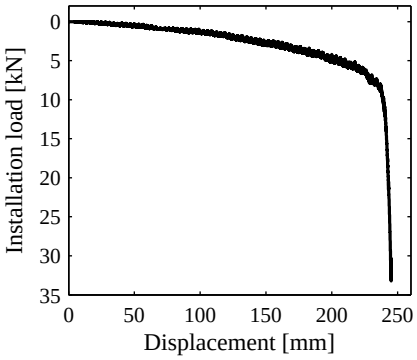

Figure 2.13: Installation 14.02.03.

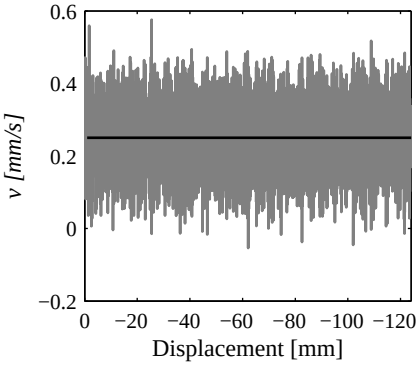

Figure 2.14: Pull-out velocity 14.02.03.

Comments:
Secondary peak in load and pore pressure response probably due to a small sudden deviation in loading velocity (possibly, higher than recorded).

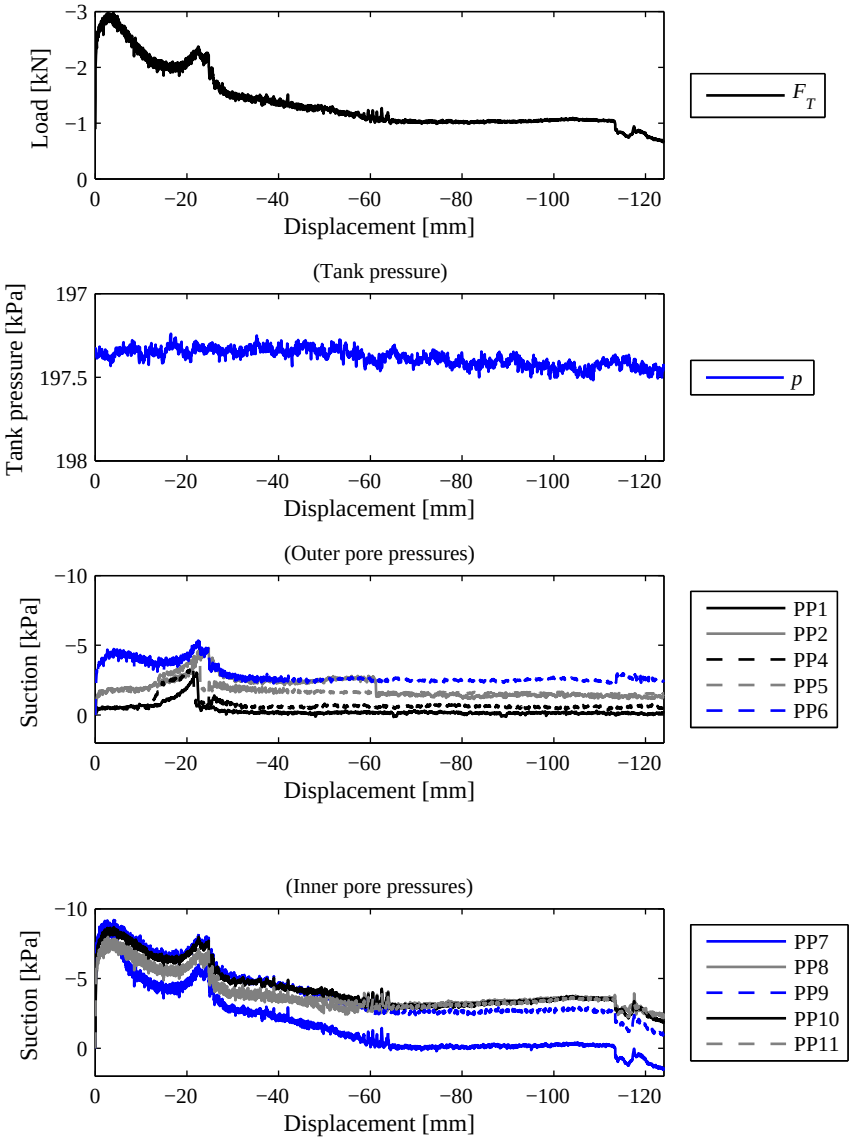

Figure 2.15: Loading 14.02.03.

2.4 Test 14.02.04

Soil properties			Loading			Installation		
D_R	[%]	88.0	f_s	[Hz]	5	F_P	[kN]	37.6
σ of D_R	[%]	3.3	F_T	[kN]	-8.02	d_{inst}	[mm]	242
γ	[kN/m^3]	19.7	w_T	[mm]	-3.61	Tank pressure		
γ'	[kN/m^3]	9.7	v	[mm/s]	1	p_t	[kPa]	200

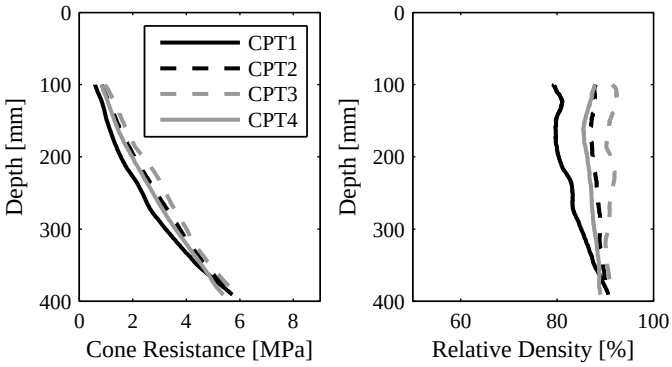

Figure 2.16: CPT testing 14.02.04.

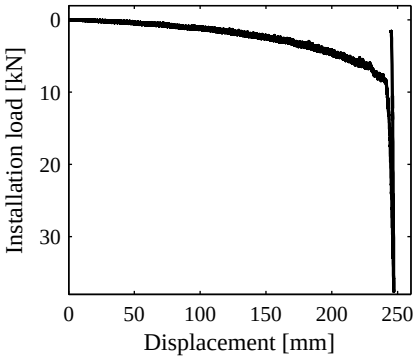

Figure 2.17: Installation 14.02.04.

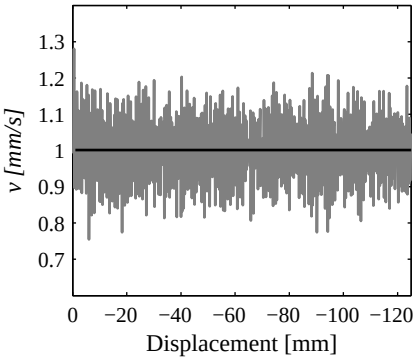

Figure 2.18: Pull-out velocity 14.02.04.

Comments:
Pressure transducer PP2 did not function.

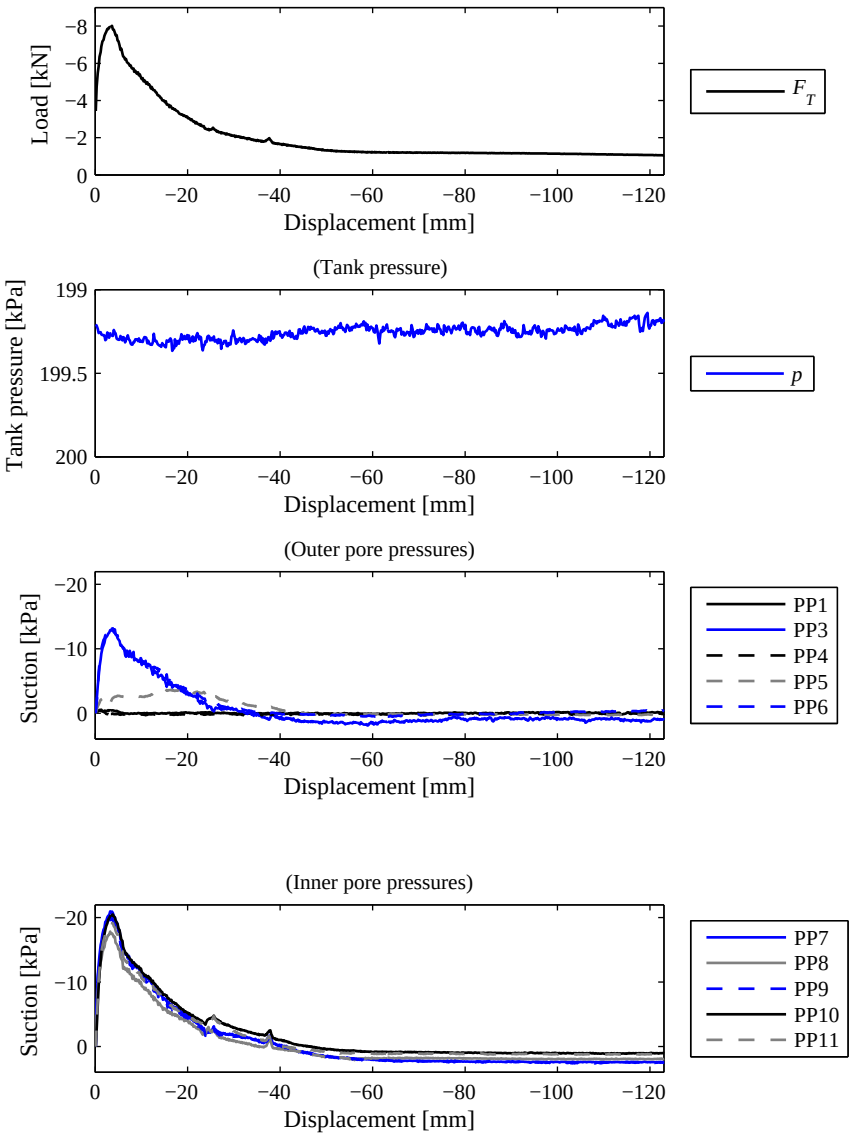

Figure 2.19: Loading 14.02.04.

2.5 Test 14.02.05

Soil properties			Loading			Installation		
D_R	[%]	90.0	f_s	[Hz]	5	F_P	[kN]	43.7
σ of D_R	[%]	4.9	F_T	[kN]	-30.79	d_{inst}	[mm]	241.5
γ	[kN/m^3]	19.8	w_T	[mm]	-16.01	Tank pressure		
γ'	[kN/m^3]	9.8	v	[mm/s]	10	p_t	[kPa]	200.9

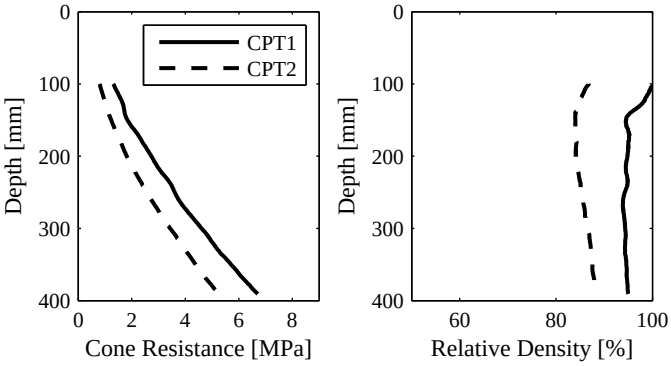

Figure 2.20: CPT testing 14.02.05.

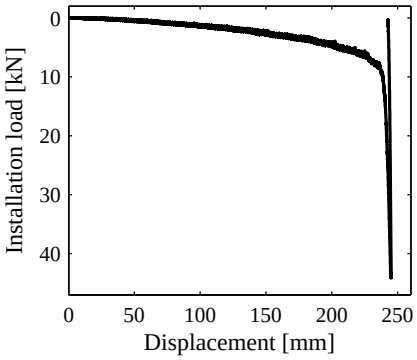

Figure 2.21: Installation 14.02.05.

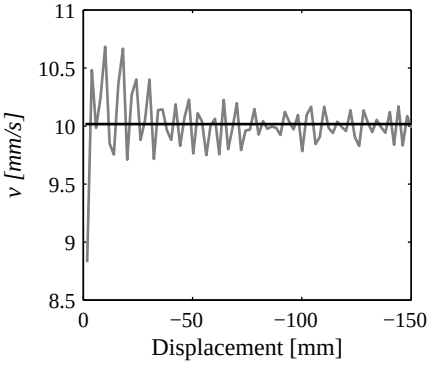

Figure 2.22: Pull-out velocity 14.02.05.

Comments:
Pore pressure response is delayed. Peak pore pressure measurement was recorded approximately 0.5 s after the peak load measurement.

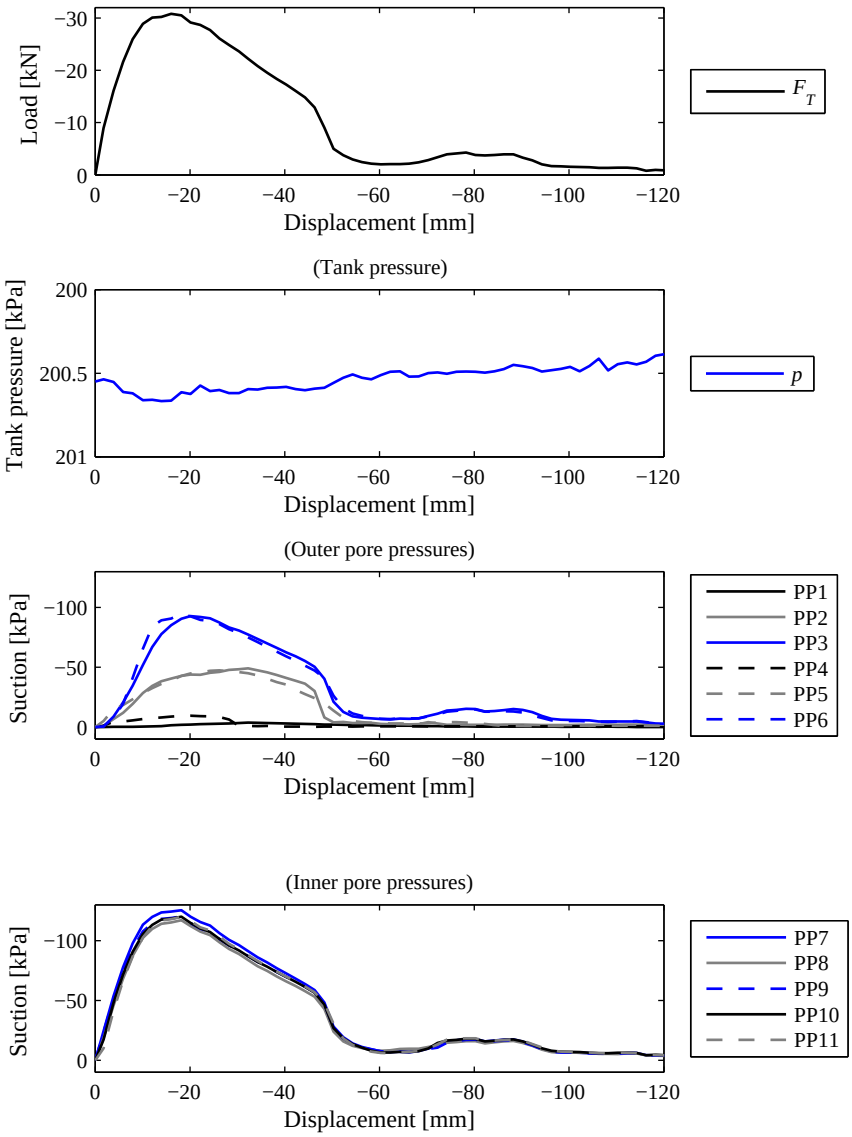

Figure 2.23: Loading 14.02.05.

2.6 Test 14.02.06

Soil properties			Loading			Installation		
D_R	[%]	87.8	f_s	[Hz]	5	F_P	[kN]	31.9
σ of D_R	[%]	3.0	F_T	[kN]	-36.94	d_{inst}	[mm]	242.3
γ	[kN/m^3]	19.7	w_T	[mm]	-22.30			
γ'	[kN/m^3]	9.7	v	[mm/s]	17.80	p_{tank}	[kPa]	199.0

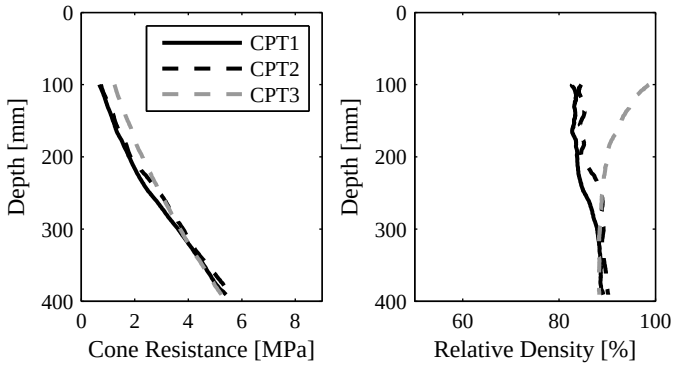

Figure 2.24: CPT testing 14.02.06.

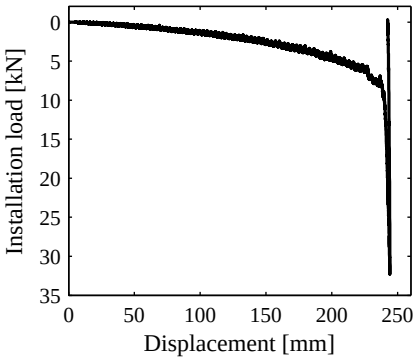

Figure 2.25: Installation 14.02.06.

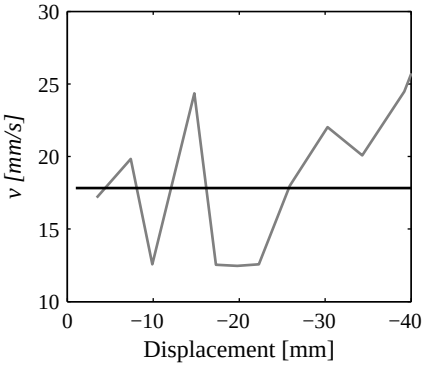

Figure 2.26: Pull-out velocity 14.02.06.

Comments:
Sampling rate was rather low for this pull-out velocity.

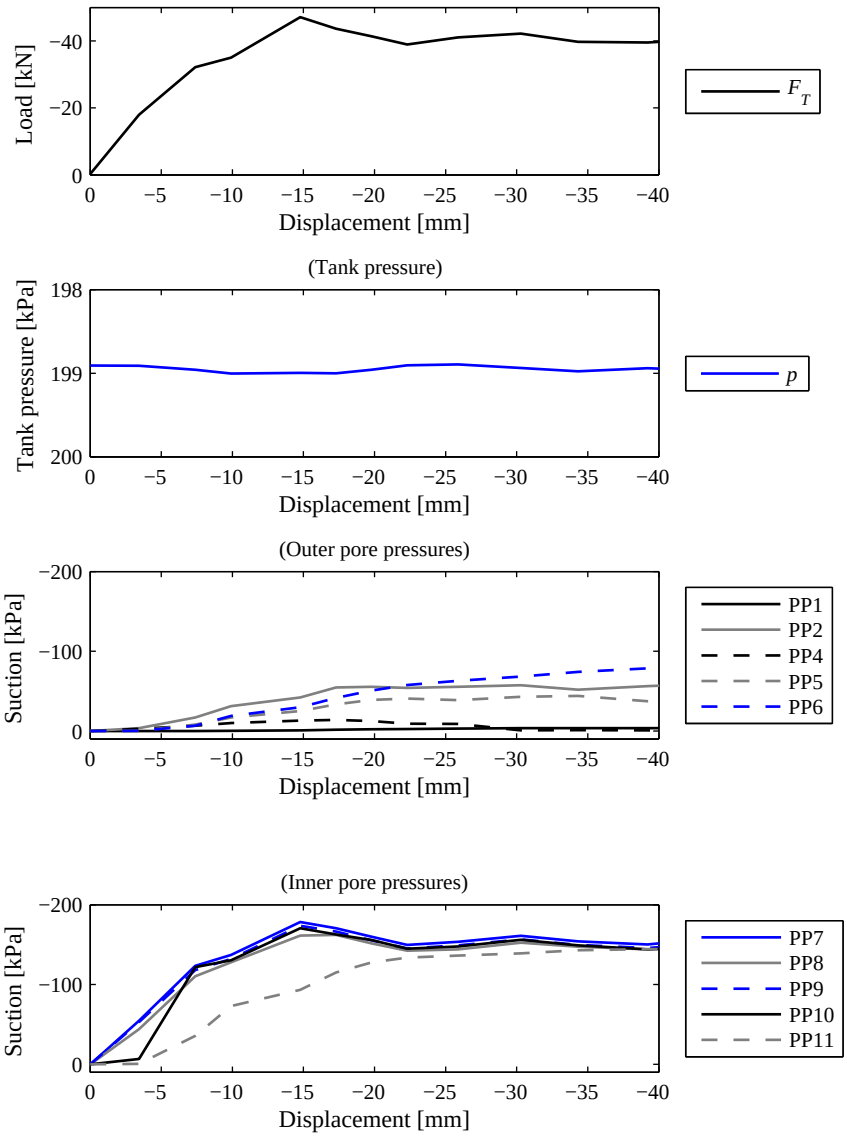

Figure 2.27: Loading 14.02.06.

2.7 Test 14.02.07

Soil properties			Loading			Installation		
D_R	[%]	83.0	f_s	[Hz]	50	F_P	[kN]	33
σ of D_R	[%]	4.9	F_T	[kN]	-44.07	d_{inst}	[mm]	236.2
γ	[kN/m^3]	19.5	w_T	[mm]	-14.73	Tank pressure		
γ'	[kN/m^3]	9.5	v	[mm/s]	21.70	p_t	[kPa]	200

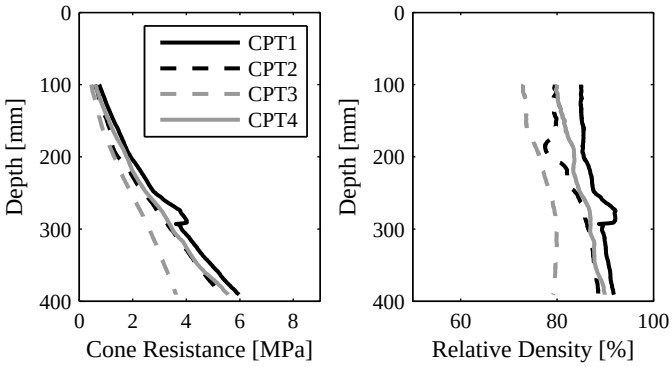

Figure 2.28: CPT testing 14.02.07.

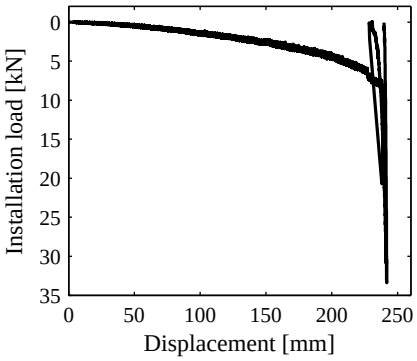

Figure 2.29: Installation 14.02.07.

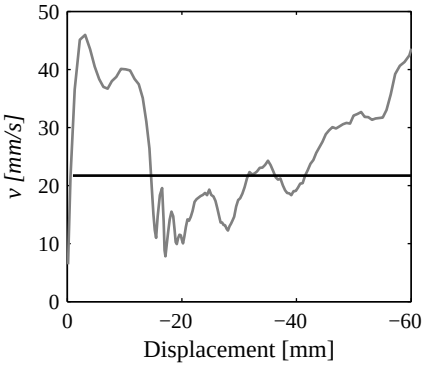

Figure 2.30: Pull-out velocity 14.02.07.

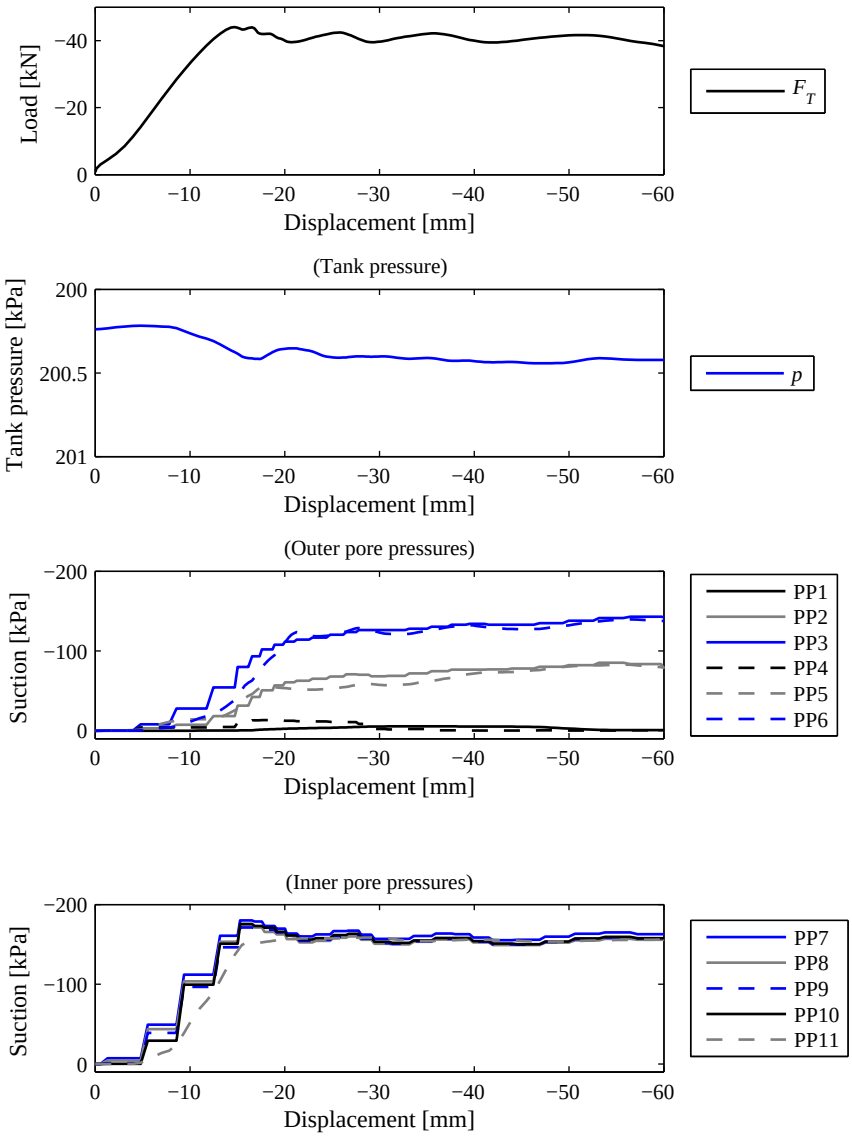

Figure 2.31: Loading 14.02.07.

Comments:
Saturation problems in transducers: PP2, PP3, PP7, PP8, PP9, PP10. Peak pore pressure measurement was recorded approximately 0.5 s after the peak load measurement.

2.8 Test 14.02.08

Soil properties			Loading			Installation		
D_R	[%]	85.0	f_s	[Hz]	100	F_P	[kN]	31.5
σ of D_R	[%]	3.7	F_T	[kN]	-48.84	d_{inst}	[mm]	239
γ	[kN/m^3]	19.6	w_T	[mm]	-14.29	Tank pressure		
γ'	[kN/m^3]	9.6	v	[mm/s]	27.2	p_t	[kPa]	200

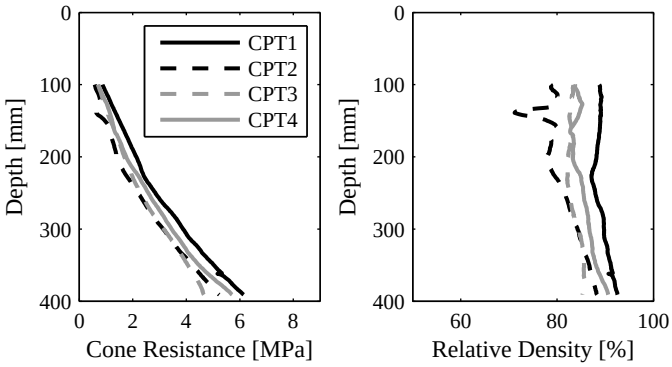

Figure 2.32: CPT testing 14.02.08.

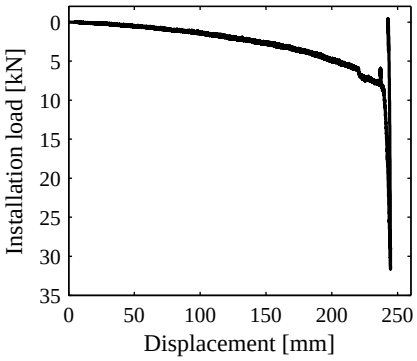

Figure 2.33: Installation 14.02.08.

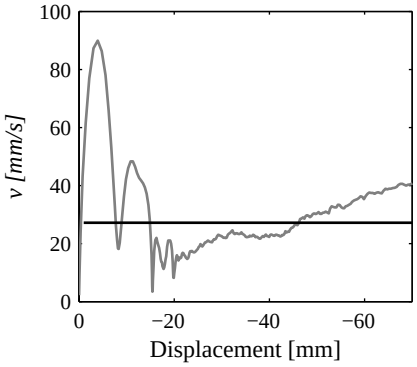

Figure 2.34: Pull-out velocity 14.02.08.

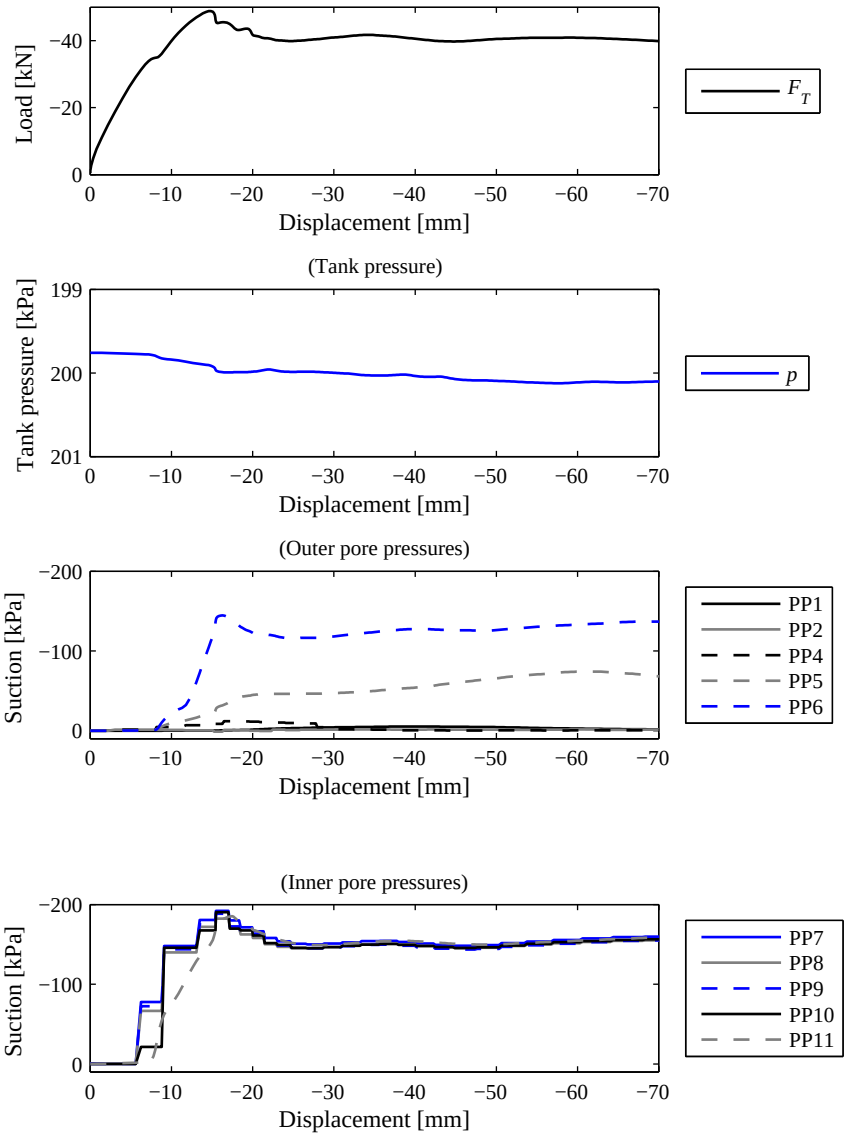

Figure 2.35: Loading 14.02.08.

Comments:
Saturation problems in transducers: PP4, PP7, PP8, PP9, PP10. Peak pore pressure measurement was recorded approximately 0.5 s after the peak load measurement.

2.9 Test 14.02.09

Soil properties			Loading			Installation		
D_R	[%]	83.0	f_s	[Hz]	100	F_P	[kN]	31.5
σ of D_R	[%]	5.4	F_T	[kN]	-65.36	d_{inst}	[mm]	236.4
γ	[kN/m^3]	19.5	w_T	[mm]	-48.78	Tank pressure		
γ'	[kN/m^3]	9.5	v	[mm/s]	46.71	p_t	[kPa]	200.4

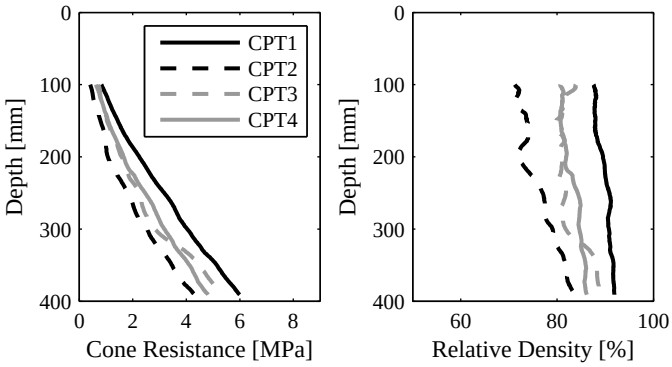

Figure 2.36: CPT testing 14.02.09.

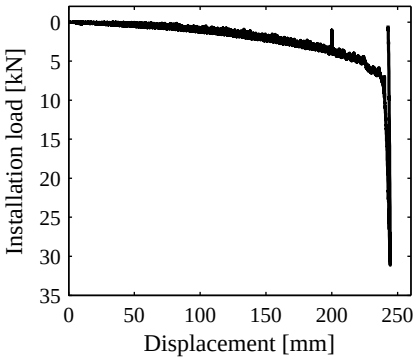

Figure 2.37: Installation 14.02.09.

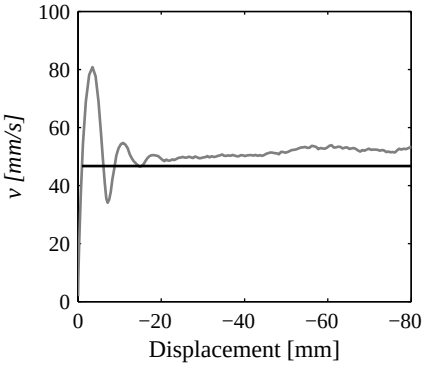

Figure 2.38: Pull-out velocity 14.02.09.

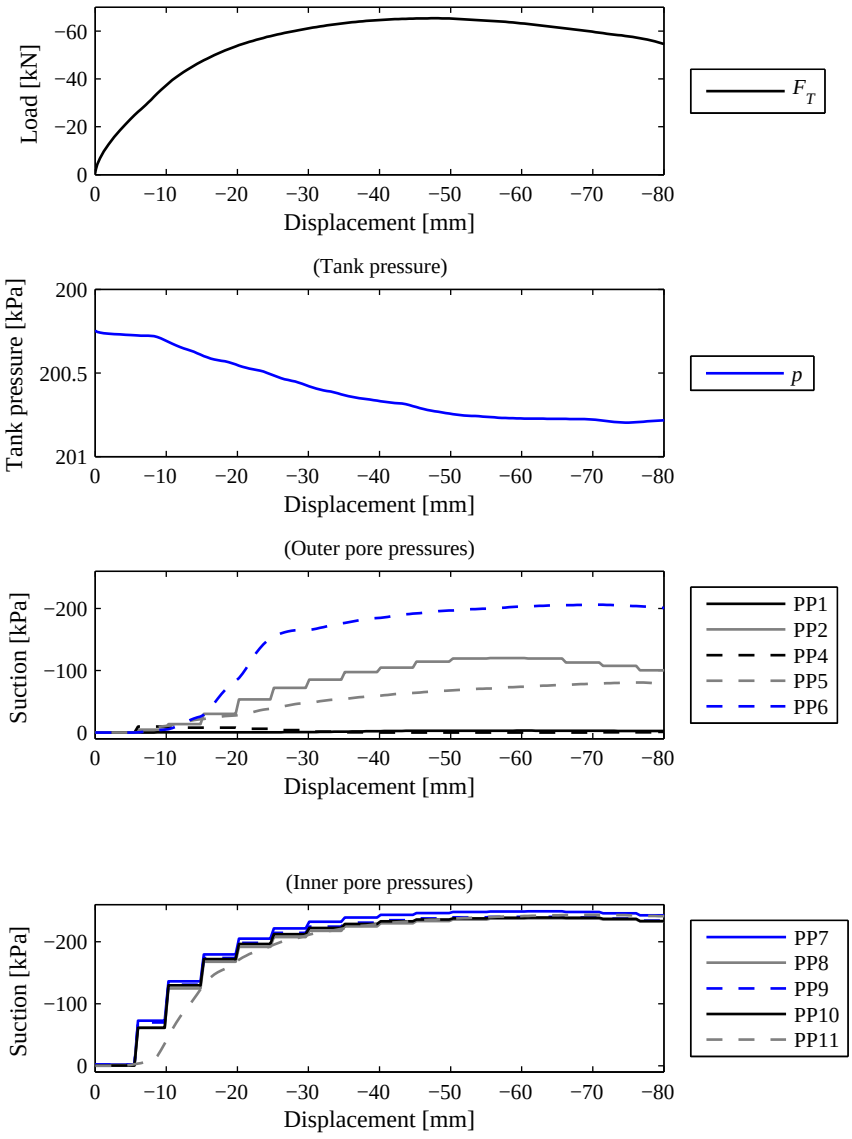

Figure 2.39: Loading 14.02.09.

Comments:
Saturation problems in transducers: PP2, PP7, PP8, PP9, PP10. Peak pore pressure measurement was recorded approximately 0.5 s after the peak load measurement.

2.10 Test 14.02.10

Soil properties			Loading			Installation		
D_R	[%]	85.8	f_s	[Hz]	5	F_P	[kN]	32.3
σ of D_R	[%]	5.2	F_T	[kN]	-	d_{inst}	[mm]	246.6
γ	[kN/m^3]	19.6	w_T	[mm]	-	Tank pressure		
γ'	[kN/m^3]	9.6	v	[mm/s]	0.05	p_t	[kPa]	200

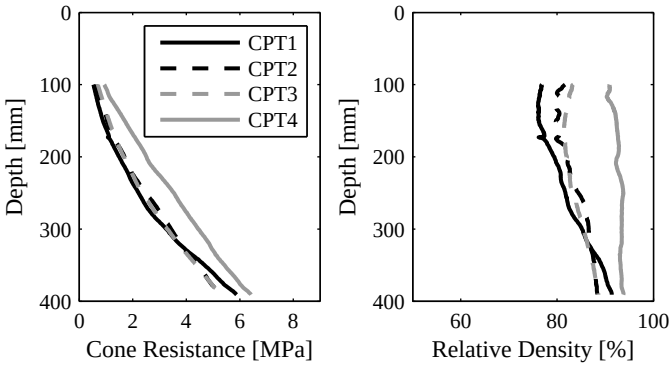

Figure 2.40: CPT testing 14.02.10.

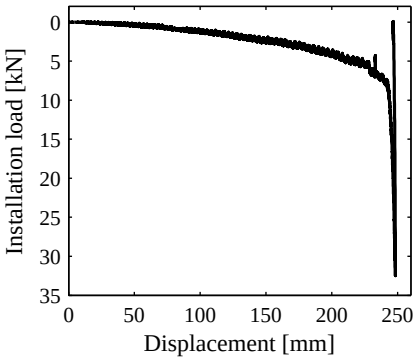

Figure 2.41: Installation 14.02.10.

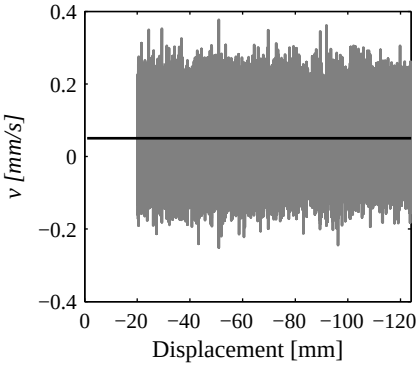

Figure 2.42: Pull-out velocity 14.02.10.

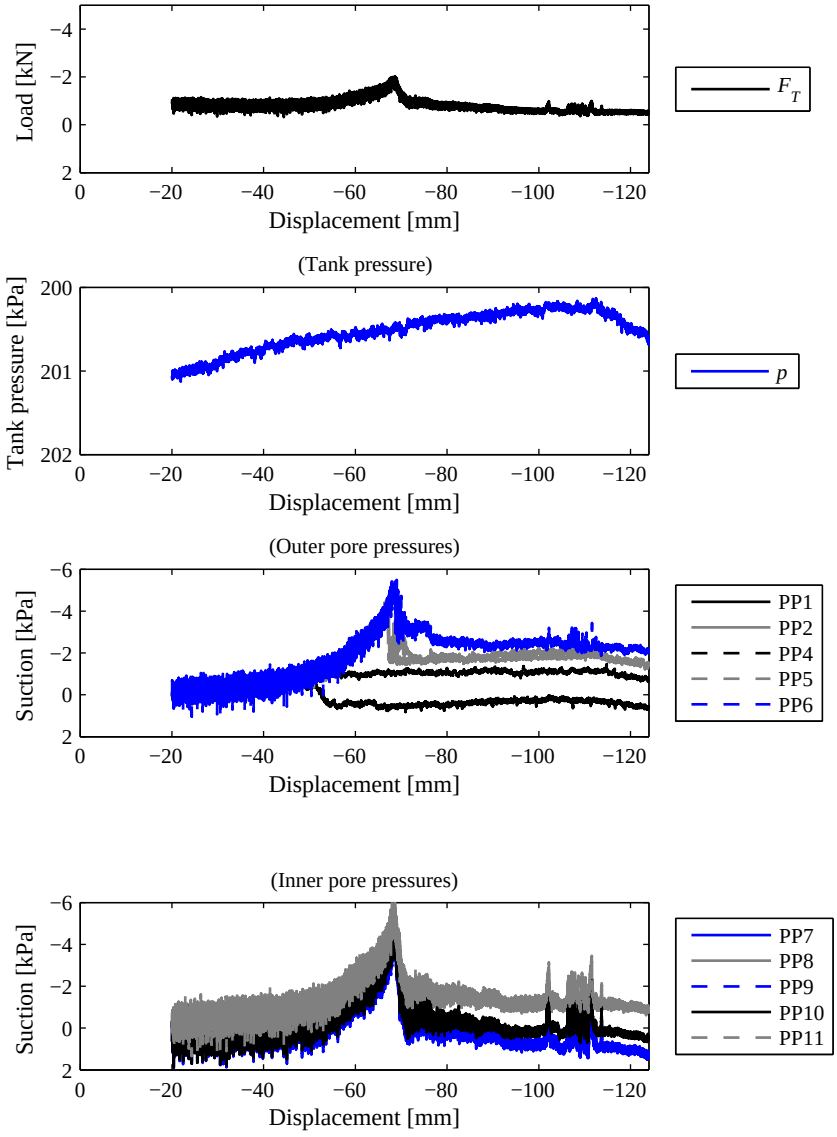

Figure 2.43: Loading 14.02.10.

Comments:
First centimetres were not recorded. Secondary peak in load and pore pressure response probably due to a small sudden deviation in loading velocity (possibly, not recorded).

2.11 Test 14.02.11

Soil properties			Loading			Installation		
D_R	[%]	86.0	f_s	[Hz]	5	F_P	[kN]	31.4
σ of D_R	[%]	4.9	F_T	[kN]	-4.08	d_{inst}	[mm]	240.7
γ	[kN/m^3]	19.6	w_T	[mm]	-0.65	Tank pressure		
γ'	[kN/m^3]	9.6	v	[mm/s]	0.1	p_t	[kPa]	199.7

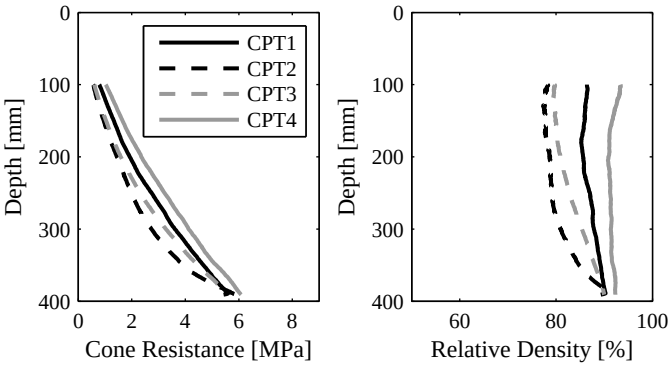

Figure 2.44: CPT testing 14.02.11.

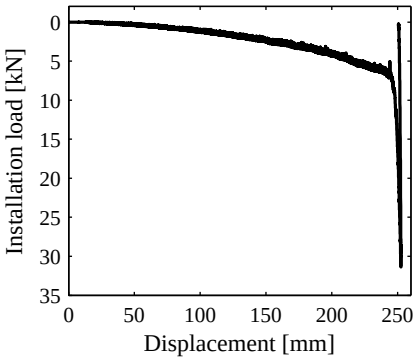

Figure 2.45: Installation 14.02.11.

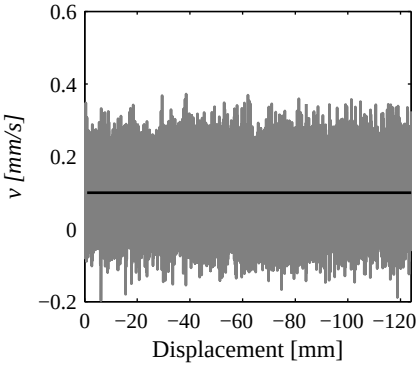

Figure 2.46: Pull-out velocity 14.02.11.

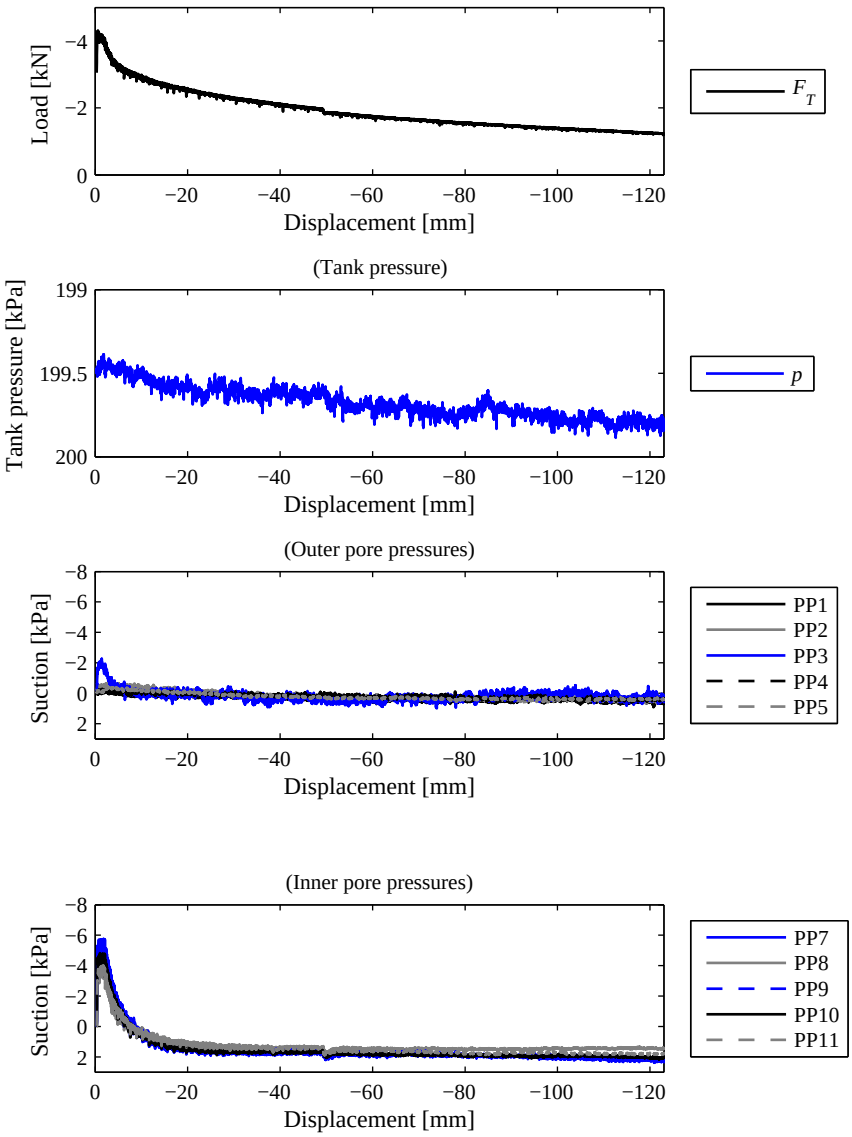

Figure 2.47: Loading 14.02.11.

2.12 Test 14.02.12

Soil properties			Loading			Installation		
D_R	[%]	85.0	f_s	[Hz]	2	F_P	[kN]	32
σ of D_R	[%]	6.4	F_T	[kN]	-2.67	d_{inst}	[mm]	239.2
γ	[kN/m^3]	19.6	w_T	[mm]	-0.70	Tank pressure		
γ'	[kN/m^3]	9.6	v	[mm/s]	0.05	p_t	[kPa]	199.6

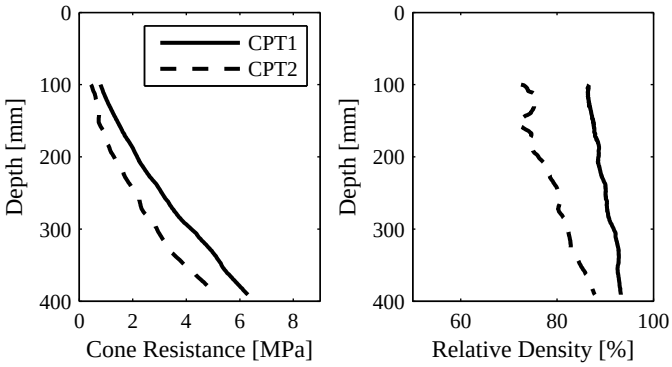

Figure 2.48: CPT testing 14.02.12.

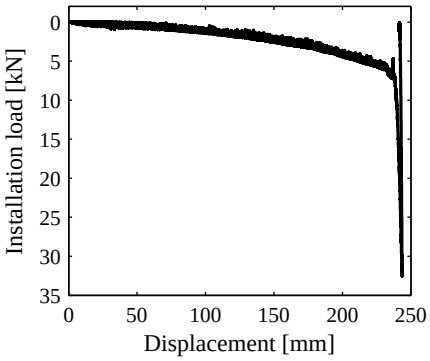

Figure 2.49: Installation 14.02.12.

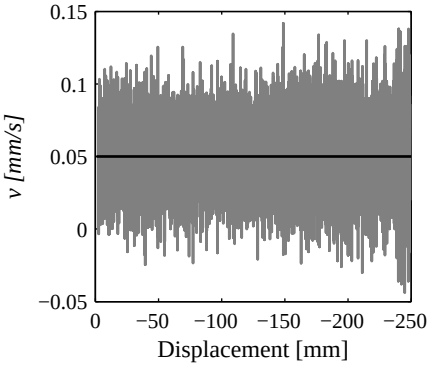

Figure 2.50: Pull-out velocity 14.02.12.

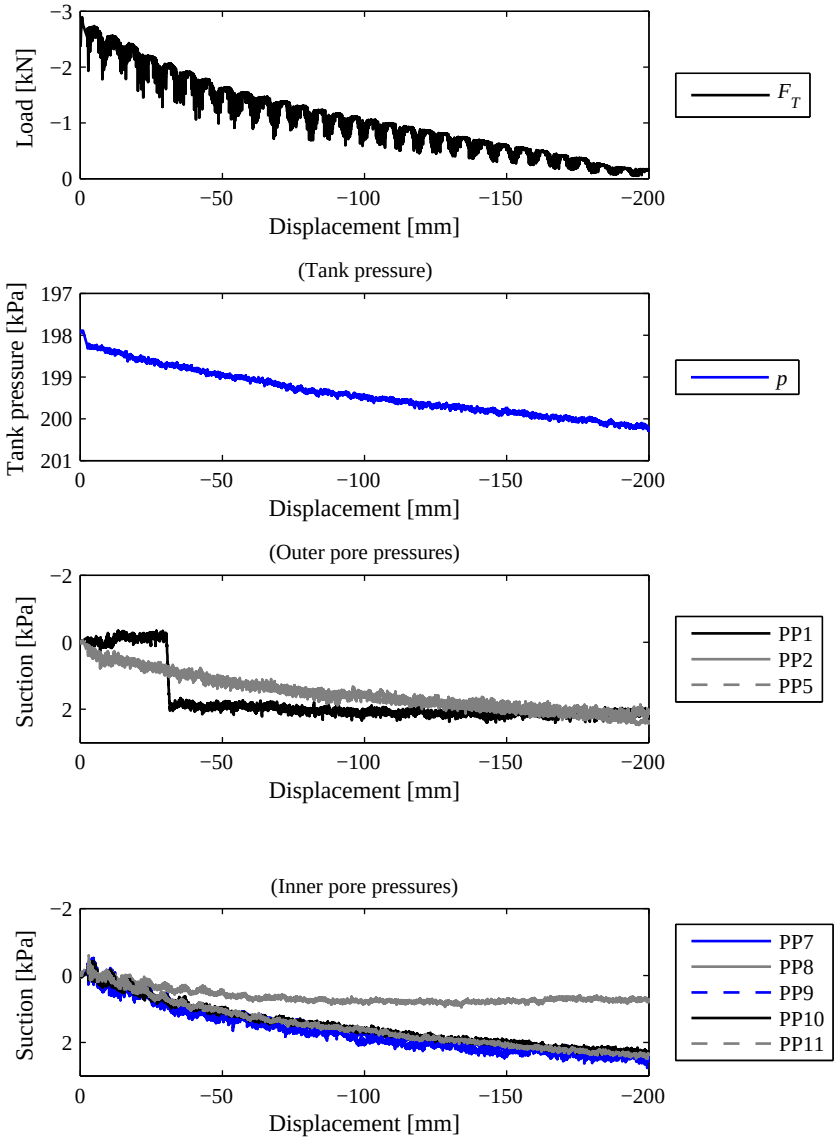

Figure 2.51: Loading 14.02.12.

Comments:
CPT tool was accidentally broken after the first two samplings. Visible change in frequency in load and pore pressure response, while the loading velocity was stable. Possibly, the vibrations were due to external works in the laboratory that affected the whole system. Pressure transducer PP1 did not function.

2.13 Test 14.02.13

Soil properties			Loading			Installation		
D_R	[%]	82.0	f_s	[Hz]	200	F_P	[kN]	31
σ of D_R	[%]	6.8	F_T	[kN]	-71.65	d_{inst}	[mm]	239.3
γ	[kN/m^3]	19.5	w_T	[mm]	-60.48	Tank pressure		
γ'	[kN/m^3]	9.5	v	[mm/s]	98.3	p_t	[kPa]	200.4

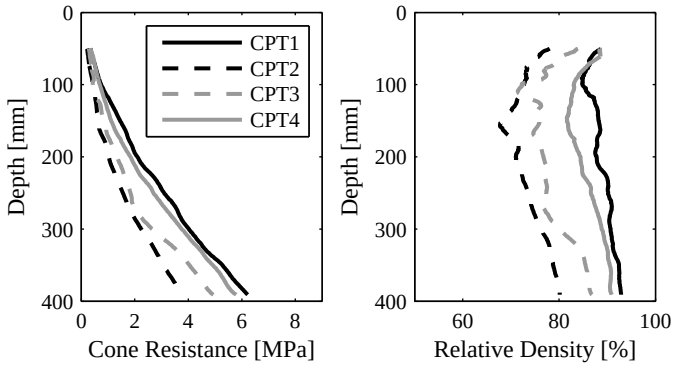

Figure 2.52: CPT testing 14.02.13.

Figure 2.53: Installation 14.02.13.

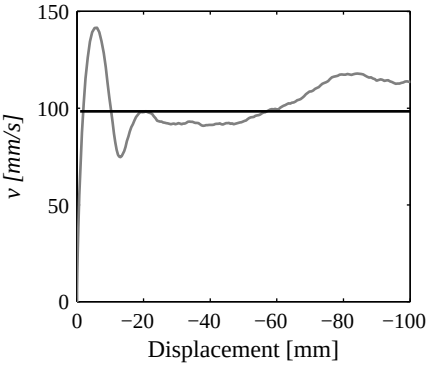

Figure 2.54: Pull-out velocity 14.02.13.

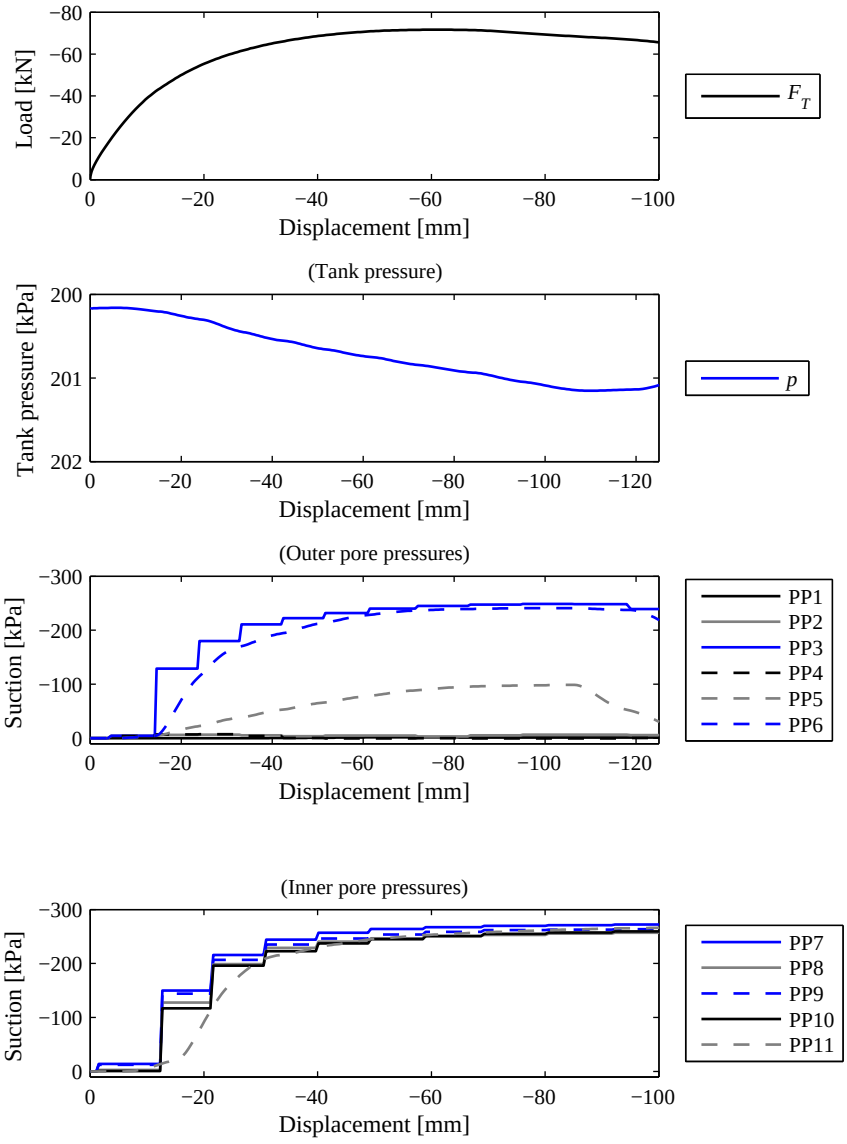

Figure 2.55: Loading 14.02.13.

Comments:
Saturation problems in transducers: PP2, PP7, PP8, PP9, PP10. Peak pore pressure measurement was recorded approximately 0.5 s after the peak load measurement.

2.14 Test 14.02.14

Soil properties			Loading			Installation		
D_R	[%]	83.5	f_s	[Hz]	500	F_P	[kN]	37
σ of D_R	[%]	3.4	F_T	[kN]	-75.17	d_{inst}	[mm]	236
γ	[kN/m^3]	19.5	w_T	[mm]	-68.18	Tank pressure		
γ'	[kN/m^3]	9.5	v	[mm/s]	152.3	p_t	[kPa]	199.7

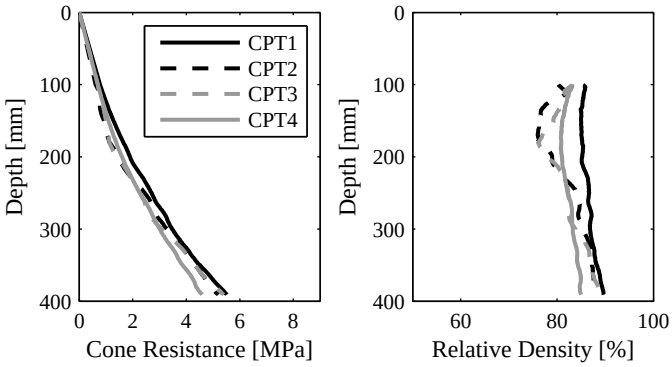

Figure 2.56: CPT testing 14.02.14.

Figure 2.57: Installation 14.02.14.

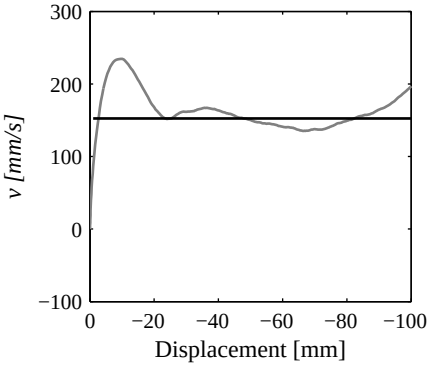

Figure 2.58: Pull-out velocity 14.02.14.

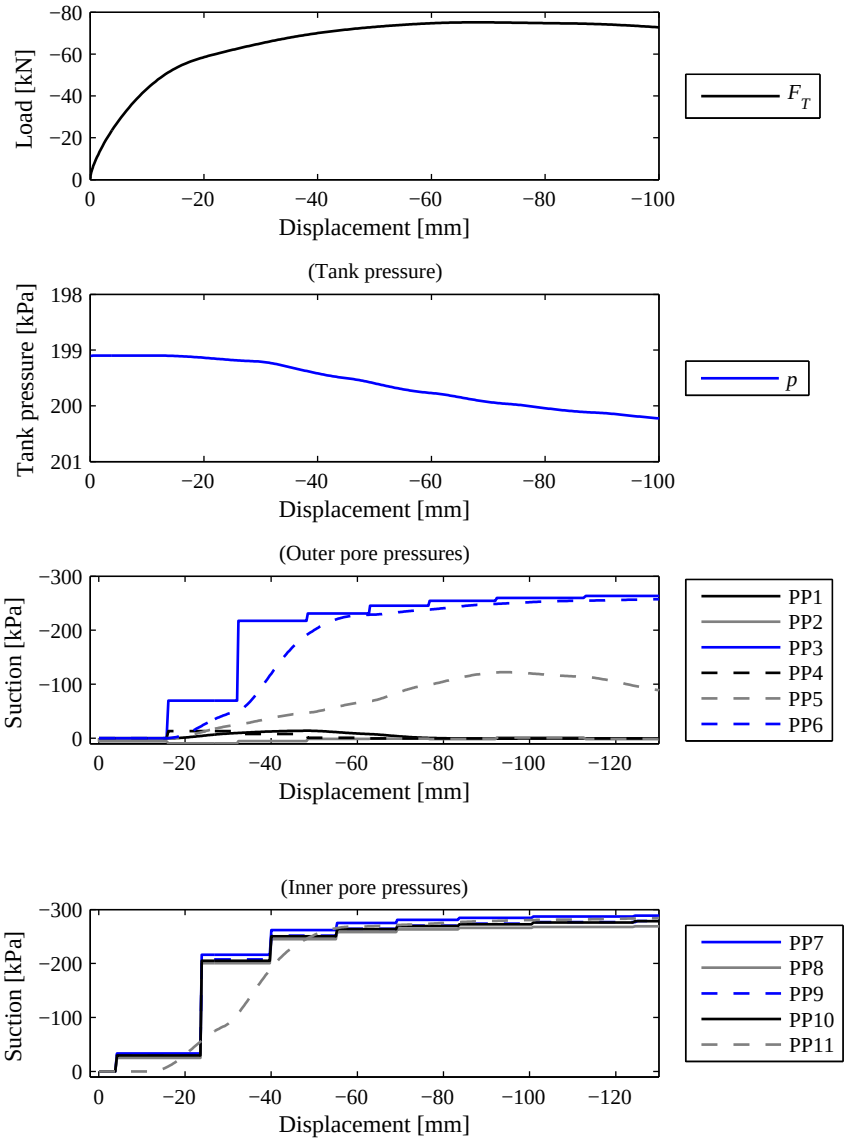

Figure 2.59: Loading 14.02.14.

Comments:
Saturation problems in transducers: PP2, PP3, PP7, PP8, PP9, PP10. Peak pore pressure measurement was recorded approximately 0.5 s after the peak load measurement.

2.15 Test 14.02.15

Soil properties			Loading			Installation		
D_R	[%]	78.6	f_s	[Hz]	1	F_P	[kN]	31
σ of D_R	[%]	6.0	F_T	[kN]	(0)	d_{inst}	[mm]	240.5
γ	[kN/m^3]	19.3	w_T	[mm]	(0)	Tank pressure		
γ'	[kN/m^3]	9.3	v	[mm/s]	0.01	p_t	[kPa]	0

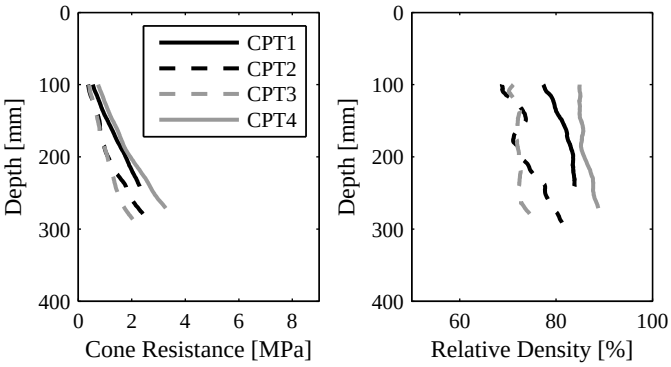

Figure 2.60: CPT testing 14.02.15.

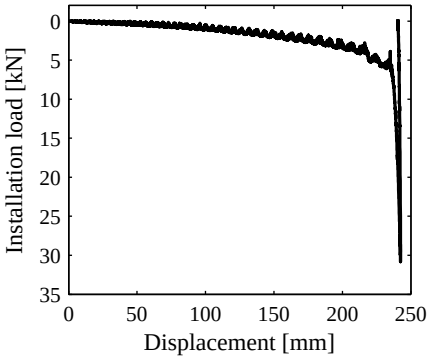

Figure 2.61: Installation 14.02.15.

Figure 2.62: Pull-out velocity 14.02.15.

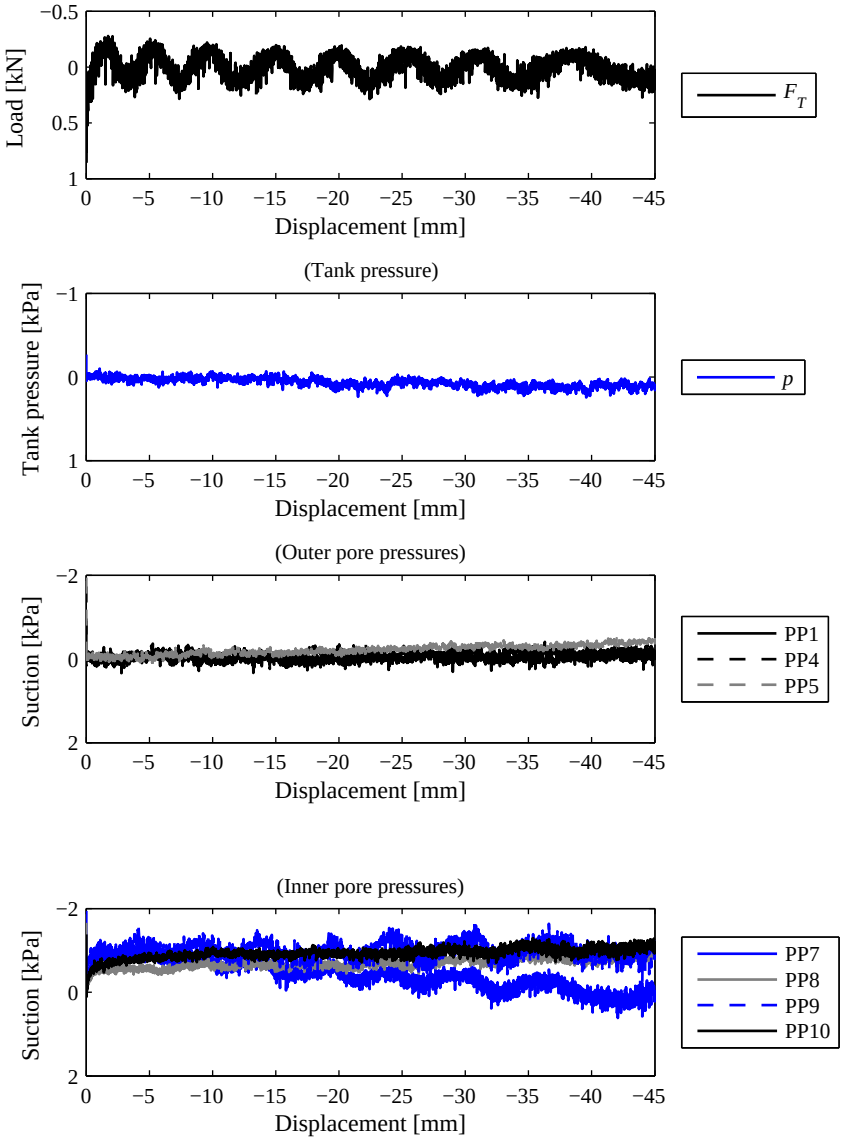

Figure 2.63: Loading 14.02.15

Comments:
No significant tensile resistance was recorded. Visible change in frequency in load and pore pressure response, while the loading velocity was stable. Possibly, the vibrations were due to external works in the laboratory that affected the whole system.

CHAPTER 3
Test Series 13.02.XX Overview

Series 13.02.XX present slow monotonic tensile loading tests on a bucket foundation model. This chapter provides the data of tests performed in the large yellow sand box (Figure 3.1). Two bucket models were used with the dimensions as follows: (1) 1.0 m in diameter D, 0.5 mm in skirt length d and (2) 1.0 m in diameter D, 1.0 mm in skirt length d. Both models had skirt thickness t = 3 mm. Figure 3.2 shows the positions of the laboratory CPT samplings. Figures 3.3 and 3.4 show the bucket foundation models. Vaitkunaite (2015) described the testing procedure. Hedegaard and Borup (1993), Ibsen and Boedker (1994) have studied the Aalborg University sand No.1 properties.

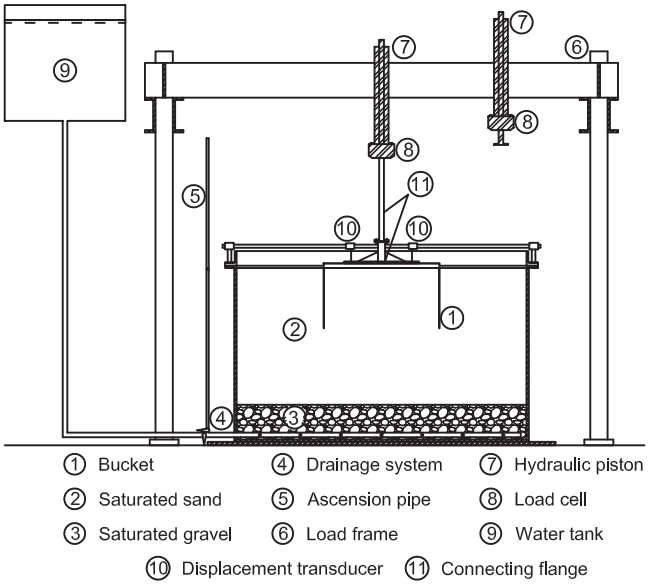

Figure 3.1: Test set-up.(Vaitkunaite 2015)

Table 3.1: Test series 13.02.XX summary.

p_m, [kPa]	Test No.	d/D	Loading			Installation		D_R, [%]	γ', [kN/m^3]
			F_T, [kN]	w_T, [mm]	v, [mm/s]	F_P, [kN]	d_{inst}, [mm]		
12	13.02.01	0.5	-26.4	-11.7	0.021	47.5	490	82.4	9.5
65	13.02.02	0.5	-53.6	-20.0	0.039	42.0	490	82.7	9.5
18	13.02.03	0.5	-	-	0.002	55.2	492	74.8	9.1
19	13.02.04	0.5	-19.0	-24.3	0.001	45.3	486	79.0	9.3
21	13.02.05	0.5	-15.3	-11.4	0.001	46.1	495	82.3	9.5
0	13.02.06	0.5	-5.7	-6.3	0.001	49.6	483	79.9	9.3
0	13.02.07	0.5	-6.3	-5.8	0.001	50.6	474	83.1	9.5
0	13.02.08	0.5	-5.3	-4.6	0.002	49.5	473	84.3	9.6
41	13.02.09	0.5	-28.2	-5.0	0.001	68.3	487	81.3	9.4
0	13.02.10	1.0	-27.7	-3.9	0.001	203.0	980	85.5	9.6
20	13.02.11	0.5	-23.3	-7.5	0.002	57.3	487	79.3	9.3
40	13.02.12	0.5	-26.9	-5.2	0.002	72.8	487	79.3	9.3
68	13.02.13	0.5	-43.2	-10.7	0.002	70.1	493	82.9	9.5
0	13.02.14	1.0	-29.8	-4.5	0.001	220.0	990	83.0	9.5
0	13.02.15	0.5	-5.9	-5.5	0.002	73.0	491	85.0	9.6
0	13.02.16	0.5	-14.9	-4.8	0.002	70.5	493	77.2	9.2
73	13.02.17	0.5	-96.3	-72.2	0.002	74.0	490	83.4	9.5

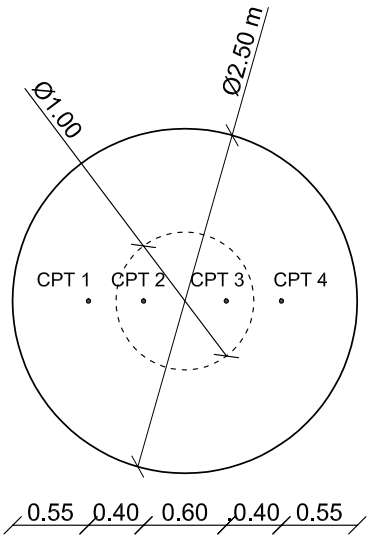

Figure 3.2: CPT positions.

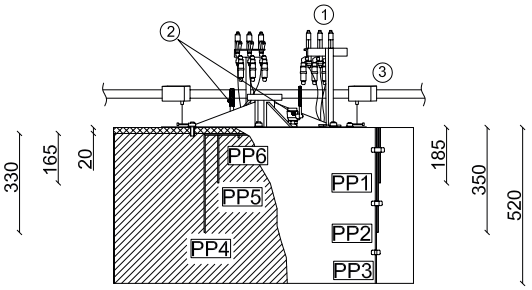

Figure 3.3: Bucket foundation model d/D = 0.5: (1) pressure transducers, (2) valves, (3) displacement transducers. (Vaitkunaite 2015)

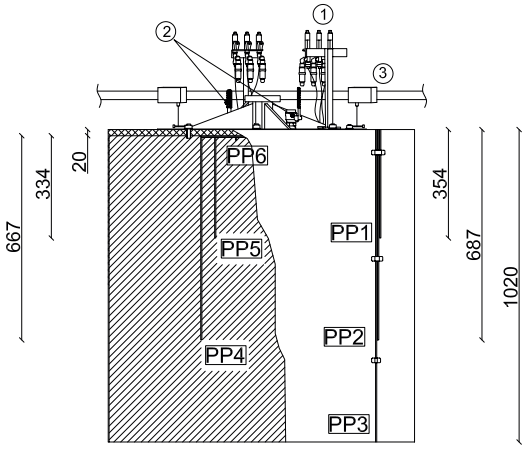

Figure 3.4: Bucket foundation model d/D = 1.0: (1) pressure transducers, (2) valves, (3) displacement transducers. (Vaitkunaite 2015)

3.1 Test 13.02.01

Soil properties			Loading			Installation		
D_R	[%]	82.4	F_T	[kN]	-26.4	F_P	[kN]	47.5
σ of D_R	[%]	3.3	w_T	[mm]	-11.68	d_{inst}	[mm]	490.0
γ	[kN/m^3]	19.5	v	[mm/s]	0.021	Membrane pressure		
γ'	[kN/m^3]	9.5				p_m	[kPa]	12

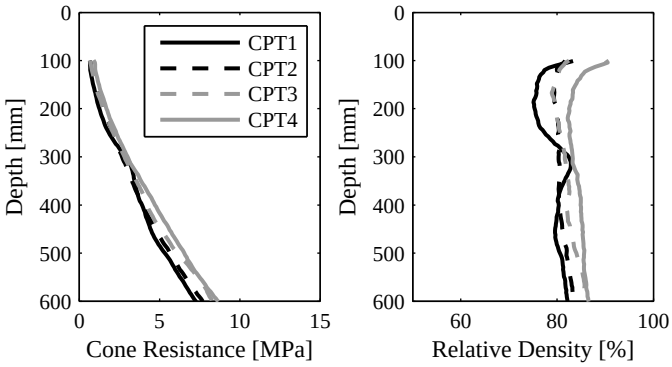

Figure 3.5: CPT testing 13.02.01.

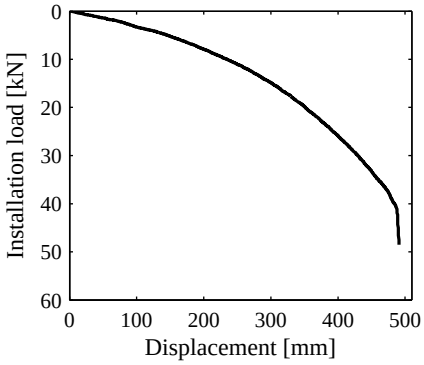

Figure 3.6: Installation 13.02.01.

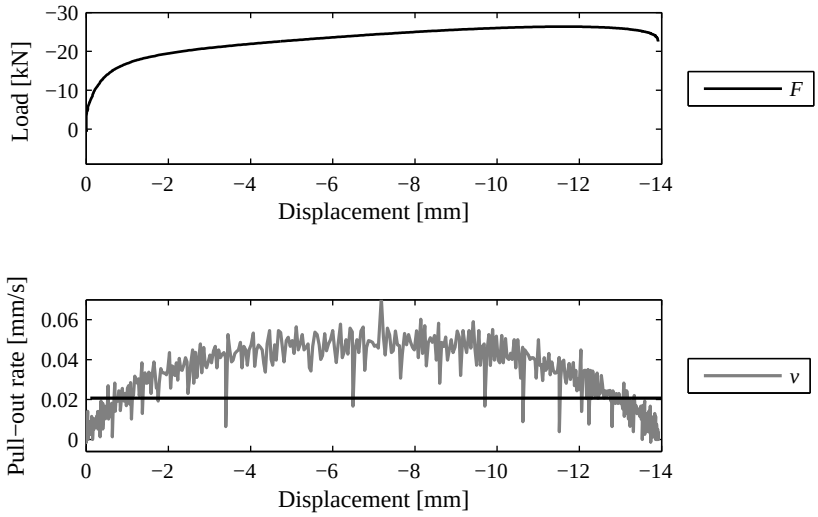

Figure 3.7: Loading 13.02.01.

3.2 Test 13.02.02

Soil properties			Loading			Installation		
D_R	[%]	82.7	F_T	[kN]	-53.6	F_P	[kN]	42.0
σ of D_R	[%]	3.8	w_T	[mm]	-20.0	d_{inst}	[mm]	490.0
γ	[kN/m^3]	19.5	v	[mm/s]	0.039	Membrane pressure		
γ'	[kN/m^3]	9.5				p_m	[kPa]	65

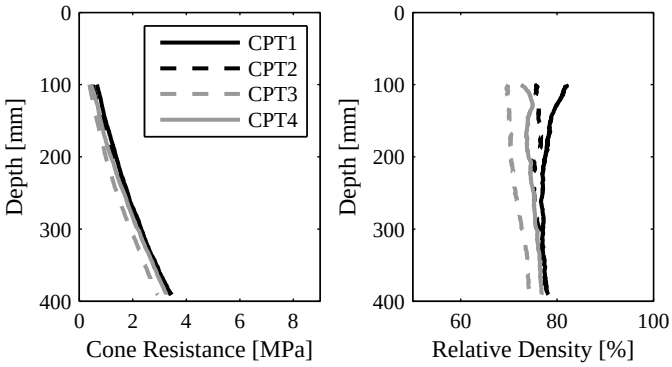

Figure 3.8: CPT testing 13.02.02.

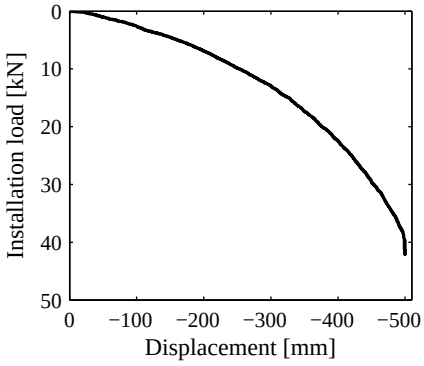

Figure 3.9: Installation 13.02.02.

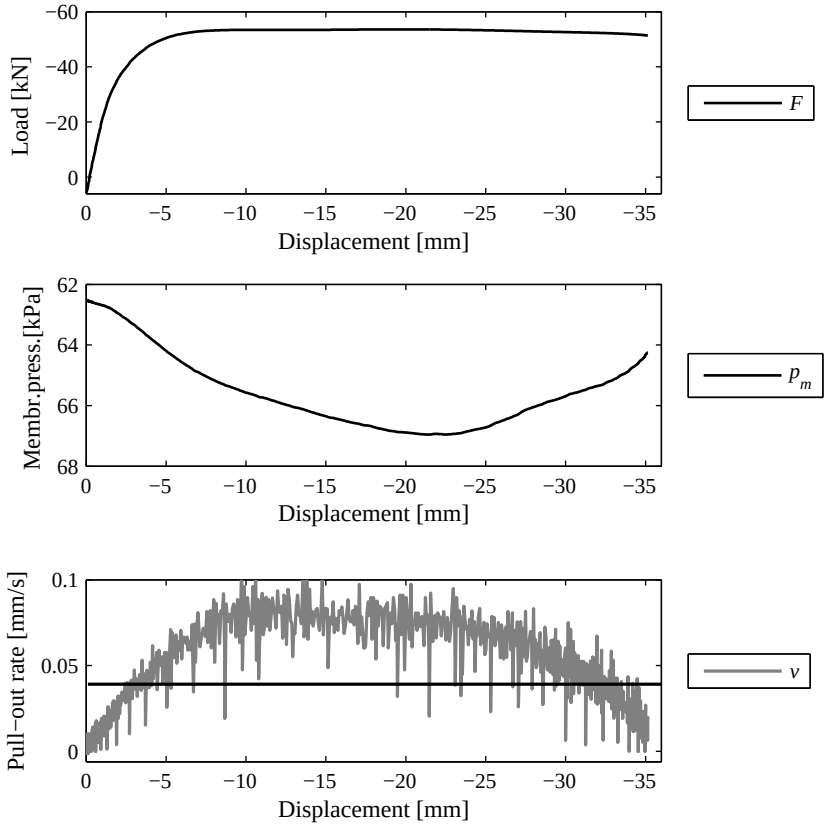

Figure 3.10: Loading 13.02.02.

3.3 Test 13.02.03

Soil properties			Loading			Installation		
D_R	[%]	74.8	F_T	[kN]	-	F_P	[kN]	55.2
σ of D_R	[%]	3.4	w_T	[mm]	-	d_{inst}	[mm]	491.8
γ	[kN/m^3]	19.1	v	[mm/s]	0.002	Membrane pressure		
γ'	[kN/m^3]	9.1				p_m	[kPa]	18

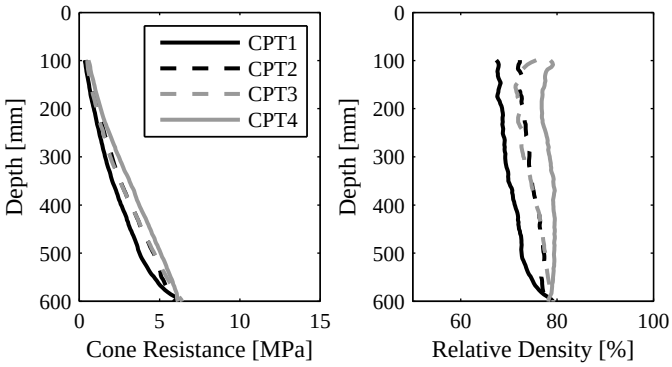

Figure 3.11: CPT testing 13.02.03.

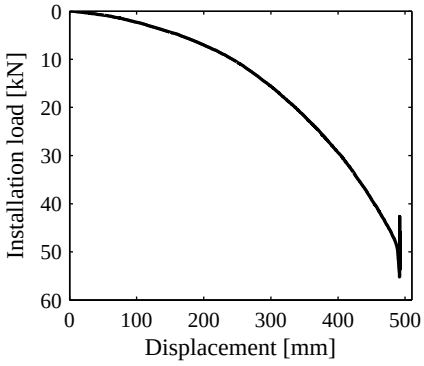

Figure 3.12: Installation 13.02.03.

Comments:
Loading was attempted to times.

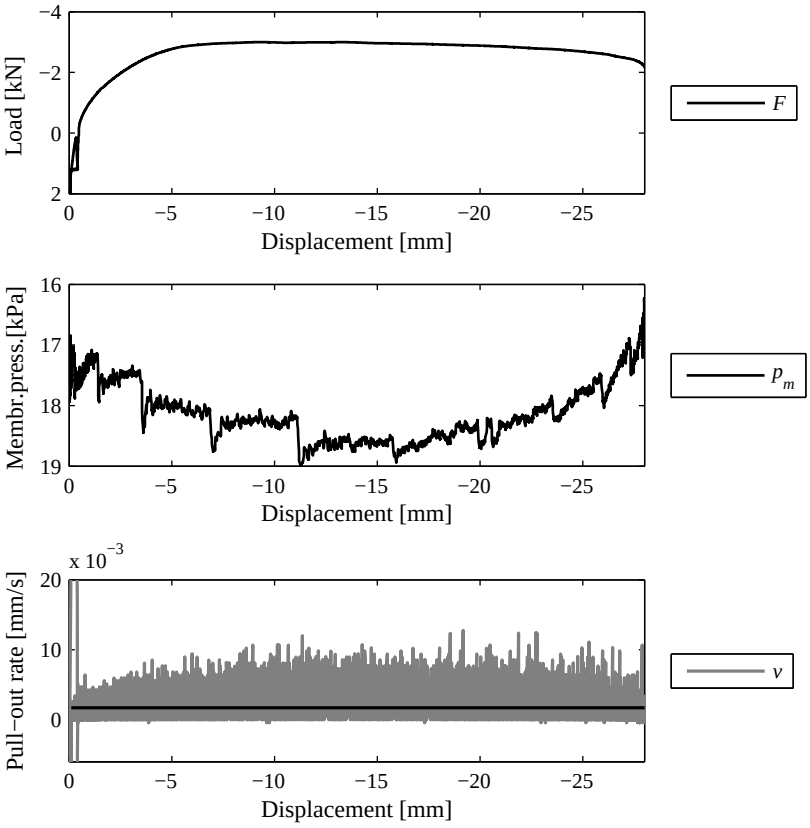

Figure 3.13: Loading 13.02.03.

3.4 Test 13.02.04

Soil properties			Loading			Installation		
D_R	[%]	79.0	F_T	[kN]	-19.0	F_P	[kN]	45.3
σ of D_R	[%]	4.4	w_T	[mm]	-24.3	d_{inst}	[mm]	486.0
γ	[kN/m^3]	19.3	v	[mm/s]	0.001	Membrane pressure		
γ'	[kN/m^3]	9.3				p_m	[kPa]	19

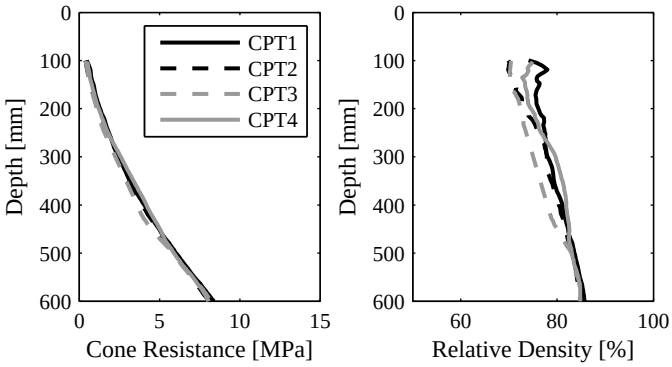

Figure 3.14: CPT testing 13.02.04.

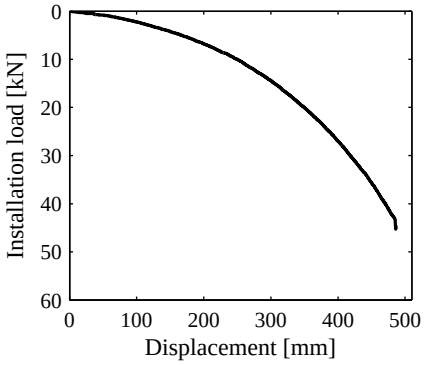

Figure 3.15: Installation 13.02.04.

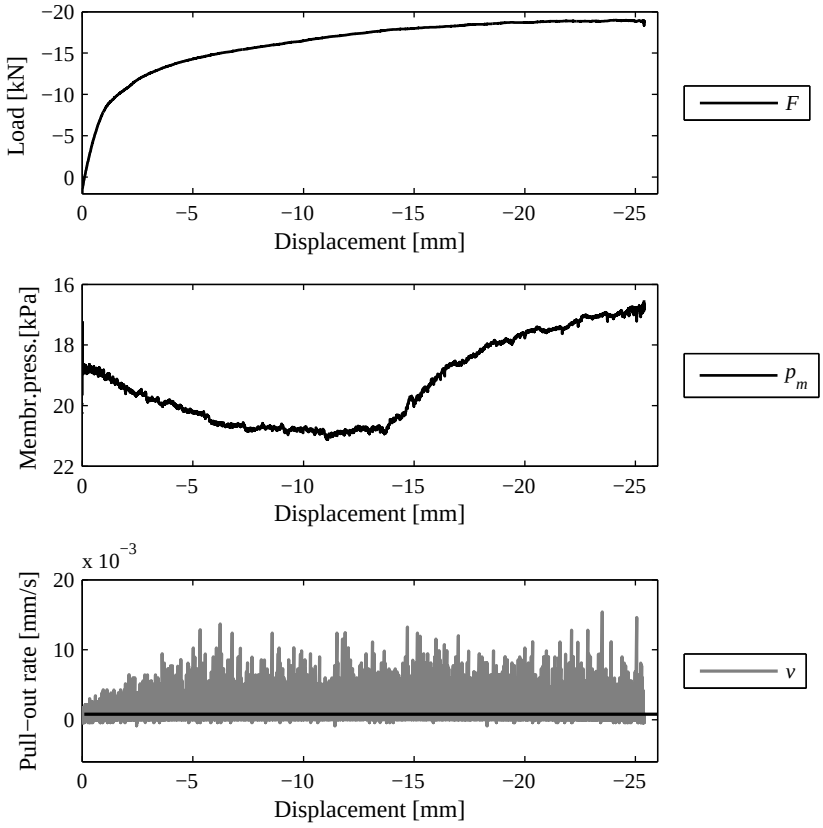

Figure 3.16: Loading 13.02.04.

3.5 Test 13.02.05

Soil properties			Loading			Installation		
D_R	[%]	82.3	F_T	[kN]	-15.3	F_P	[kN]	46.1
σ of D_R	[%]	4.2	w_T	[mm]	-11.4	d_{inst}	[mm]	495.0
γ	[kN/m^3]	19.5	v	[mm/s]	0.005	Membrane pressure		
γ'	[kN/m^3]	9.5				p_m	[kPa]	21

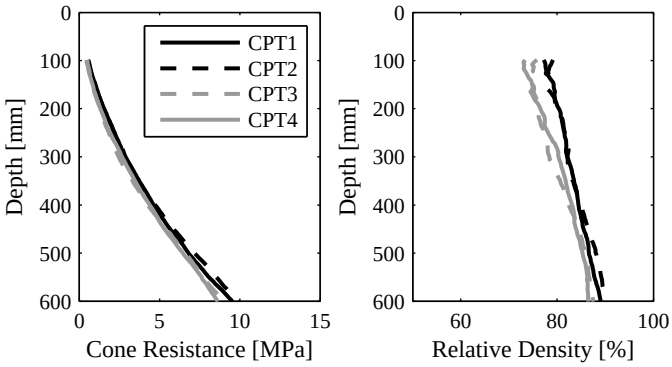

Figure 3.17: CPT testing 13.02.05.

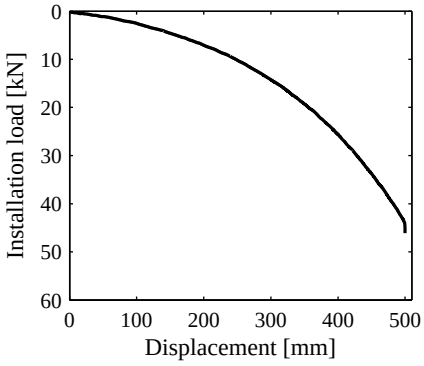

Figure 3.18: Installation 13.02.05.

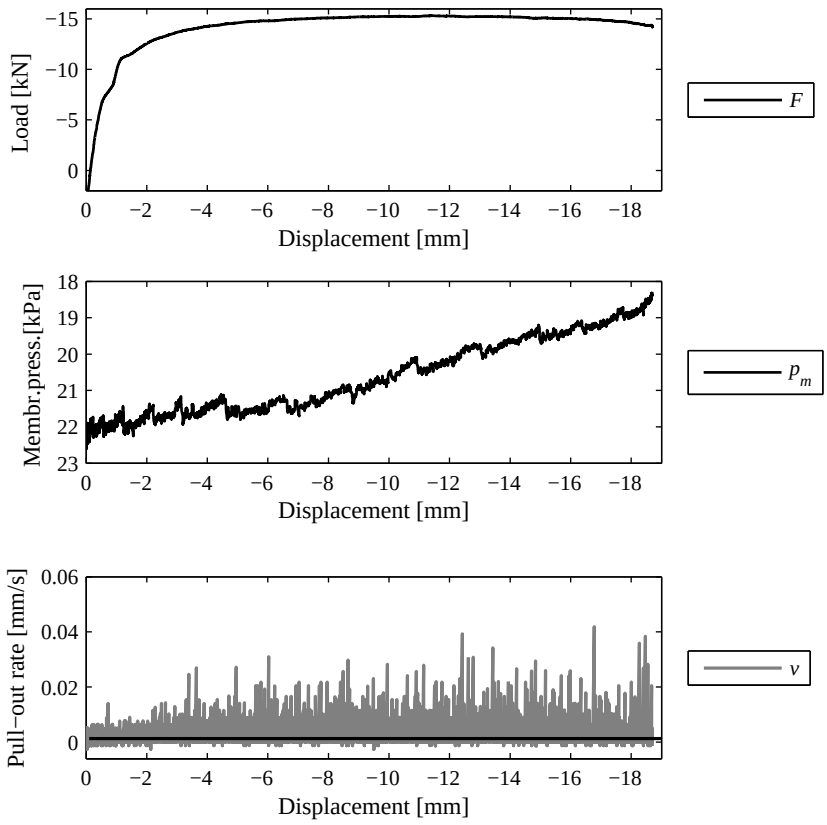

Figure 3.19: Loading 13.02.05.

3.6 Test 13.02.06

Soil properties			Loading			Installation		
D_R	[%]	79.9	F_T	[kN]	-5.7	F_P	[kN]	49.6
σ of D_R	[%]	4.3	w_T	[mm]	-6.3	d_{inst}	[mm]	483.0
γ	[kN/m^3]	19.3	v	[mm/s]	0.001	Membrane pressure		
γ'	[kN/m^3]	9.3				p_m	[kPa]	0

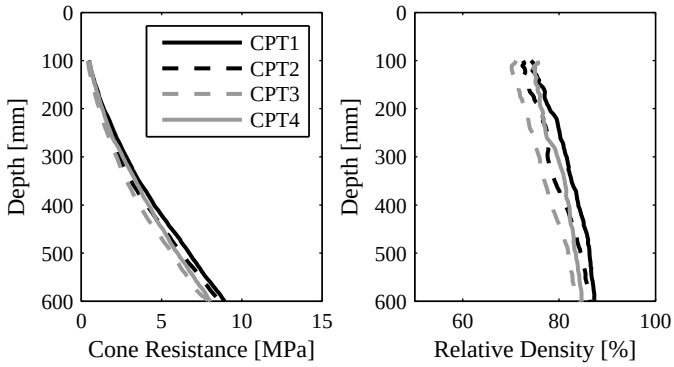

Figure 3.20: CPT testing 13.02.06.

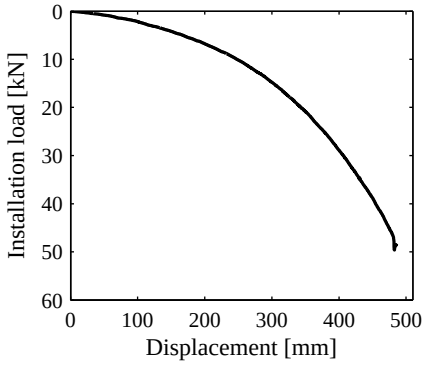

Figure 3.21: Installation 13.02.06.

Comments:
Pore pressure transducer PP1 did not function.

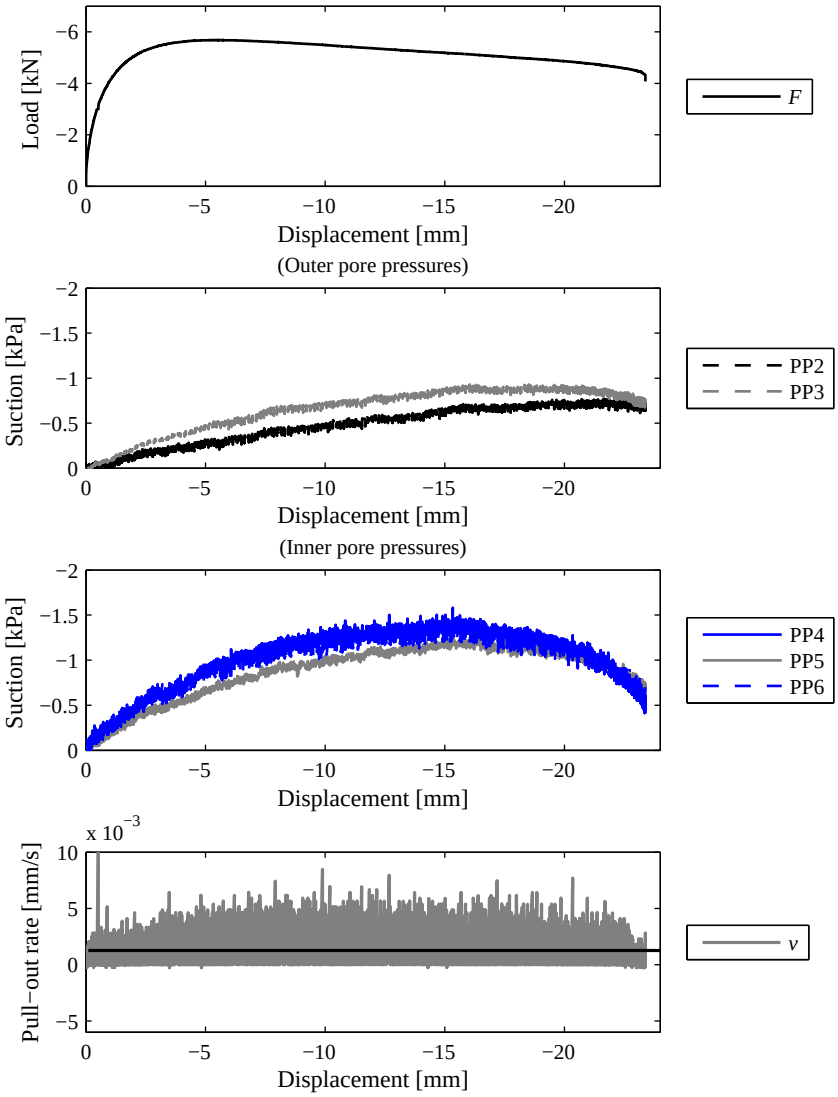

Figure 3.22: Loading 13.02.06.

3.7 Test 13.02.07

Soil properties			Loading			Installation		
D_R	[%]	83.1	F_T	[kN]	-6.3	F_P	[kN]	50.6
σ of D_R	[%]	4.4	w_T	[mm]	-5.8	d_{inst}	[mm]	474.0
γ	[kN/m^3]	19.5	v	[mm/s]	0.001	Membrane pressure		
γ'	[kN/m^3]	9.5				p_m	[kPa]	0

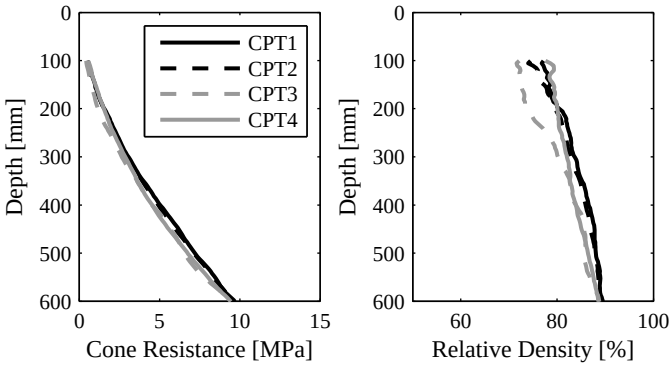

Figure 3.23: CPT testing 13.02.07.

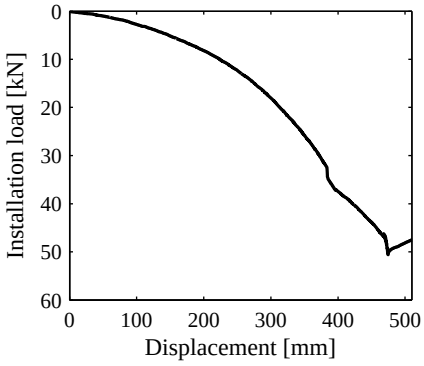

Figure 3.24: Installation 13.02.07.

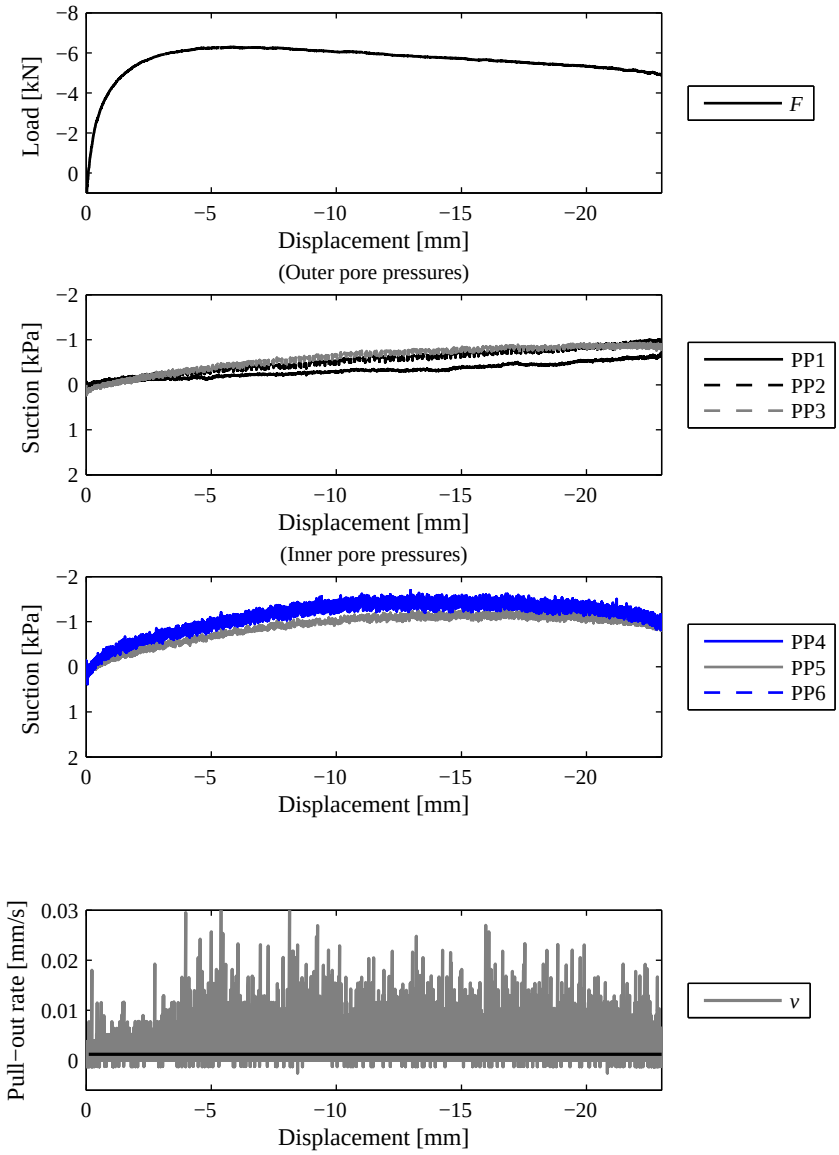

Figure 3.25: Loading 13.02.07.

3.8 Test 13.02.08

Soil properties			Loading			Installation		
D_R	[%]	84.3	F_T	[kN]	-5.3	F_P	[kN]	49.5
σ of D_R	[%]	4.0	w_T	[mm]	-4.6	d_{inst}	[mm]	473.0
γ	[kN/m^3]	19.6	v	[mm/s]	0.002	Membrane pressure		
γ'	[kN/m^3]	9.6				p_m	[kPa]	0

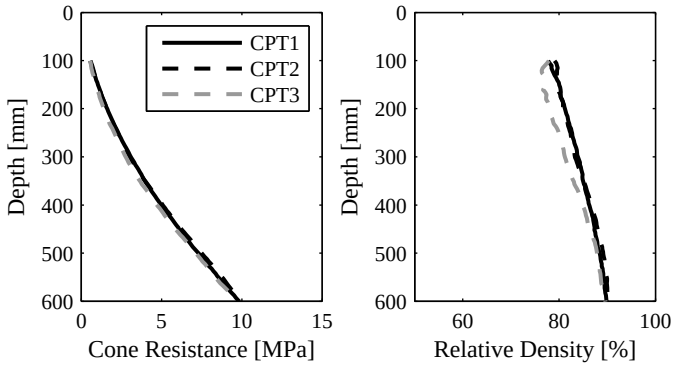

Figure 3.26: CPT testing 13.02.08.

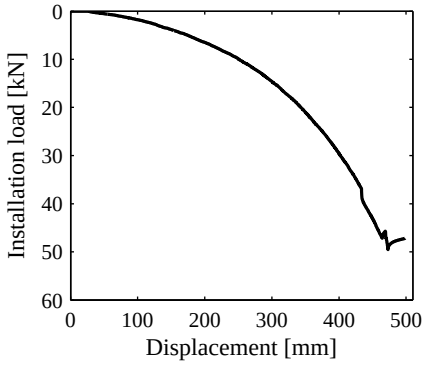

Figure 3.27: Installation 13.02.08.

Comments:
Pore pressure transducer PP1 did not function.

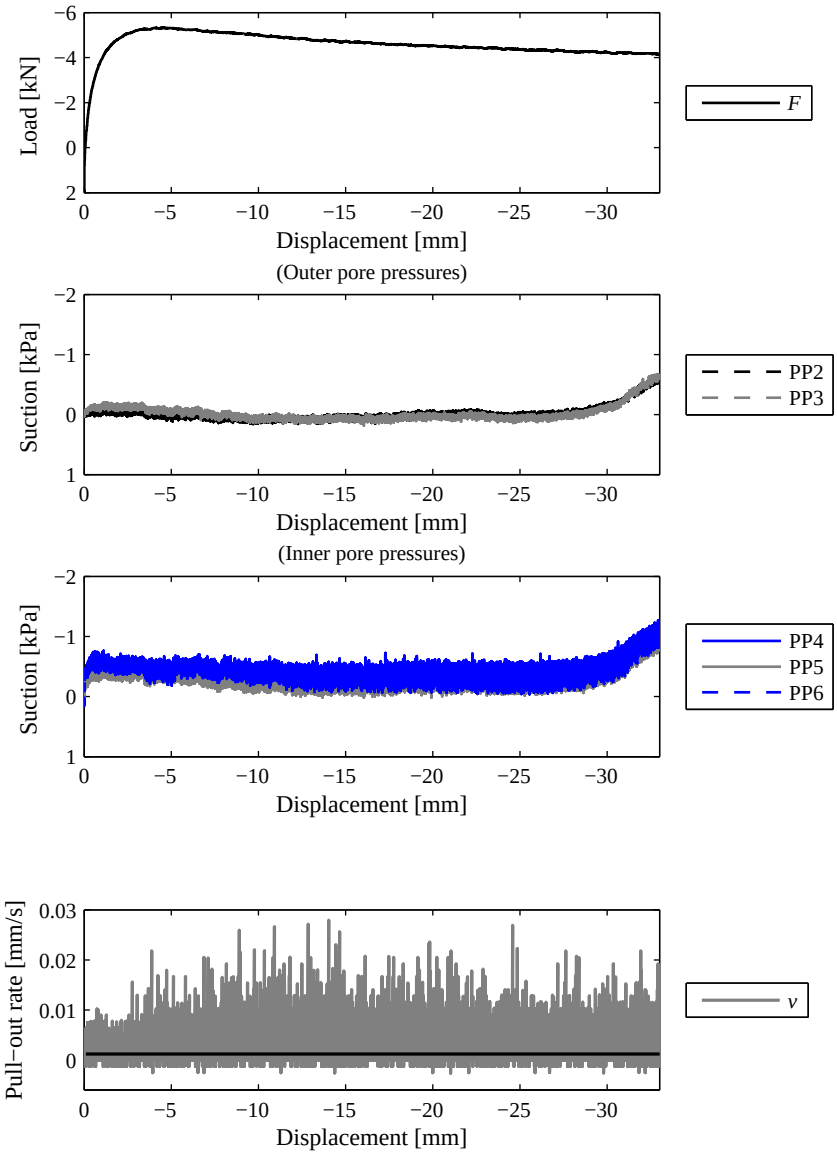

Figure 3.28: Loading 13.02.08.

3.9 Test 13.02.09

Soil properties			Loading			Installation		
D_R	[%]	81.3	F_T	[kN]	-28.2	F_P	[kN]	68.3
σ of D_R	[%]	3.2	w_T	[mm]	-5.0	d_{inst}	[mm]	487.0
γ	[kN/m^3]	19.4	v	[mm/s]	0.001	Membrane pressure		
γ'	[kN/m^3]	9.4				p_m	[kPa]	41

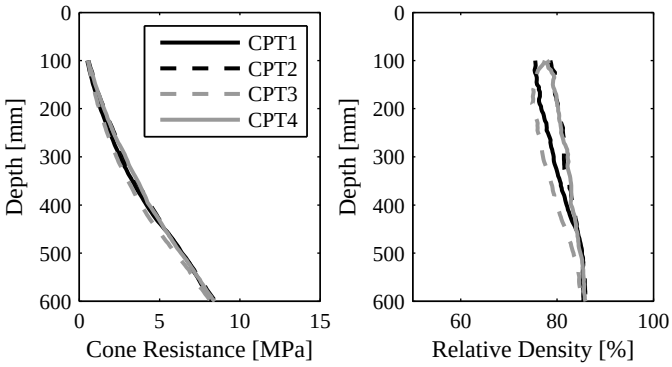

Figure 3.29: CPT testing 13.02.09.

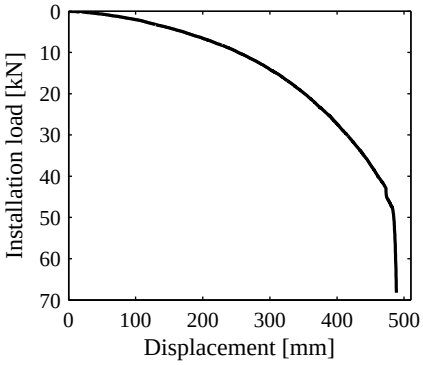

Figure 3.30: Installation 13.02.09.

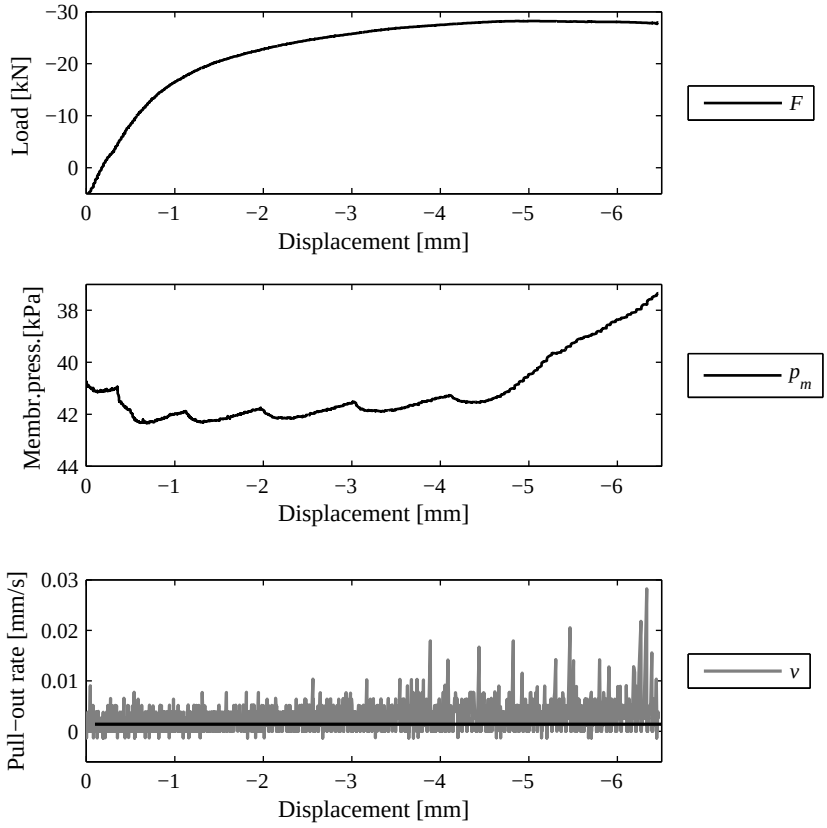

Figure 3.31: Loading 13.02.09.

3.10 Test 13.02.10

Soil properties			Loading			Installation		
D_R	[%]	85.5	F_T	[kN]	-27.7	F_P	[kN]	203
σ of D_R	[%]	4.8	w_T	[mm]	-3.9	d_{inst}	[mm]	980.0
γ	[kN/m^3]	19.6	v	[mm/s]	0.001	Membrane pressure		
γ'	[kN/m^3]	9.6				p_m	[kPa]	0

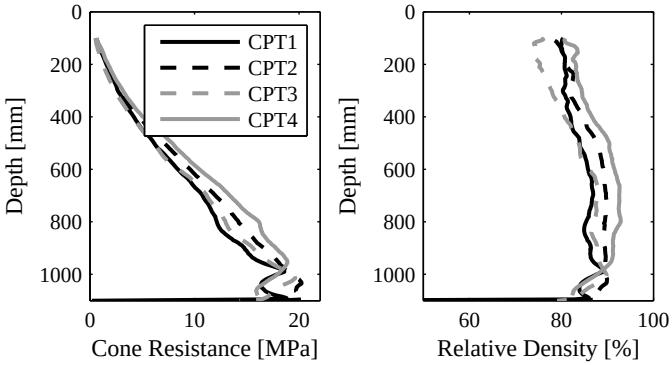

Figure 3.32: CPT testing 13.02.10.

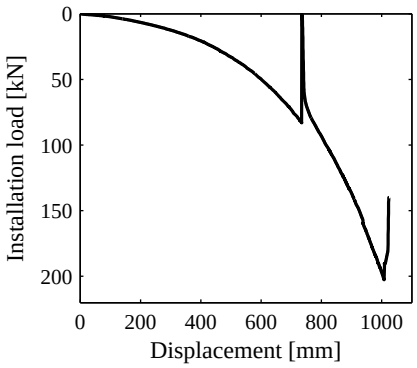

Figure 3.33: Installation 13.02.10.

Comments:
Bucket d/D = 1. Installation performed in two steps due to insufficient piston length.

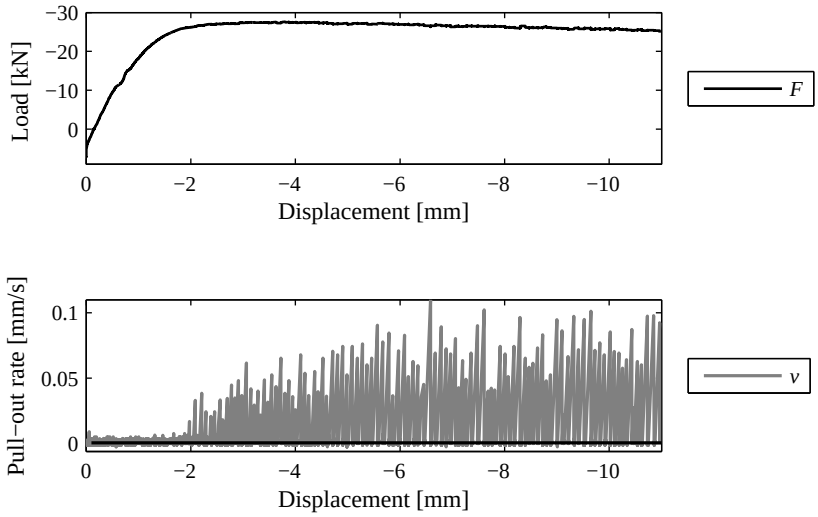

Figure 3.34: Loading 13.02.10.

3.11 Test 13.02.11

Soil properties			Loading			Installation		
D_R	[%]	79.3	F_T	[kN]	-23.3	F_P	[kN]	57.3
σ of D_R	[%]	3.0	w_T	[mm]	-7.5	d_{inst}	[mm]	487.0
γ	[kN/m^3]	19.3	v	[mm/s]	0.002	Membrane pressure		
γ'	[kN/m^3]	9.3				p_m	[kPa]	20

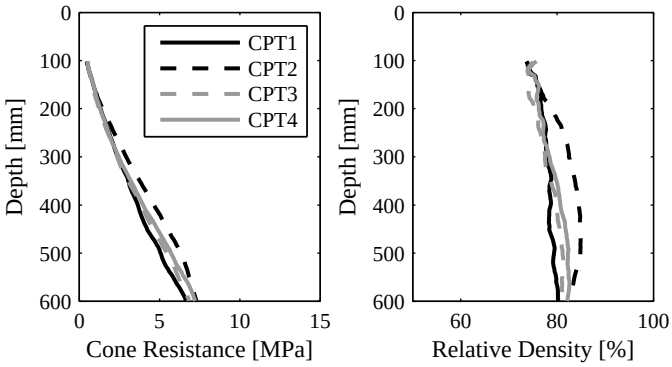

Figure 3.35: CPT testing 13.02.11.

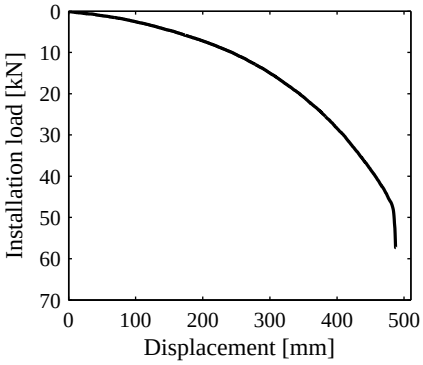

Figure 3.36: Installation 13.02.11.

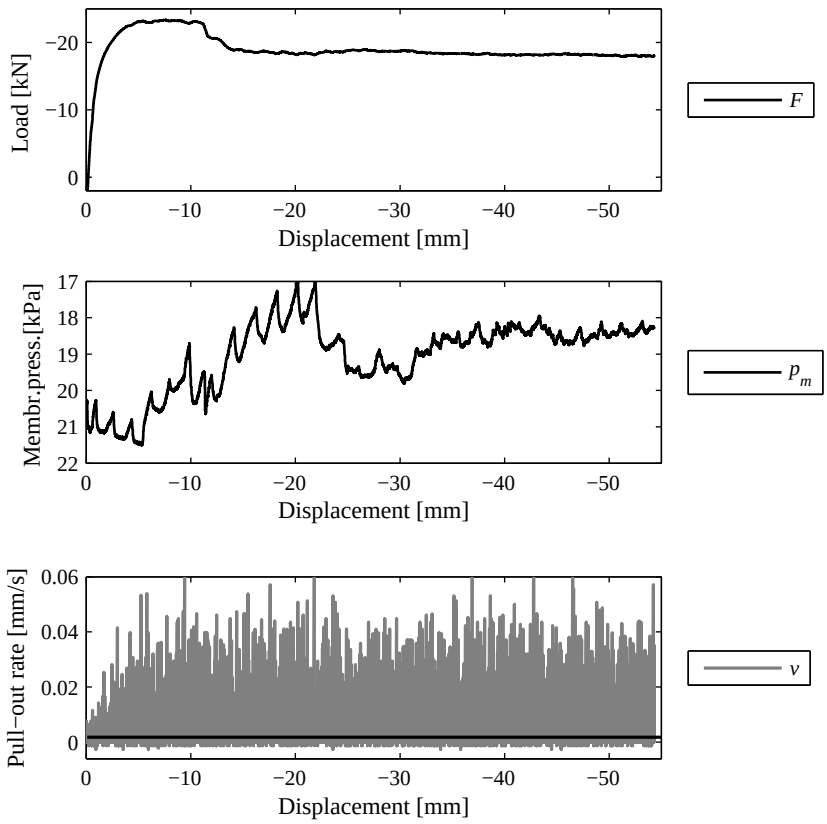

Figure 3.37: Loading 13.02.11.

3.12 Test 13.02.12

Soil properties			Loading			Installation		
D_R	[%]	79.3	F_T	[kN]	-26.9	F_P	[kN]	72.8
σ of D_R	[%]	4.0	w_T	[mm]	-5.2	d_{inst}	[mm]	487.0
γ	[kN/m^3]	19.3	v	[mm/s]	0.002	Membrane pressure		
γ'	[kN/m^3]	9.3				p_m	[kPa]	40

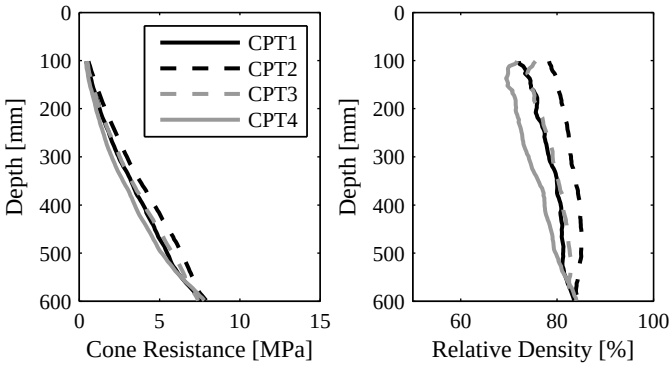

Figure 3.38: CPT testing 13.02.12.

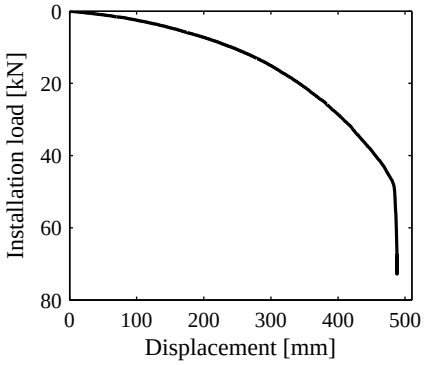

Figure 3.39: Installation 13.02.12.

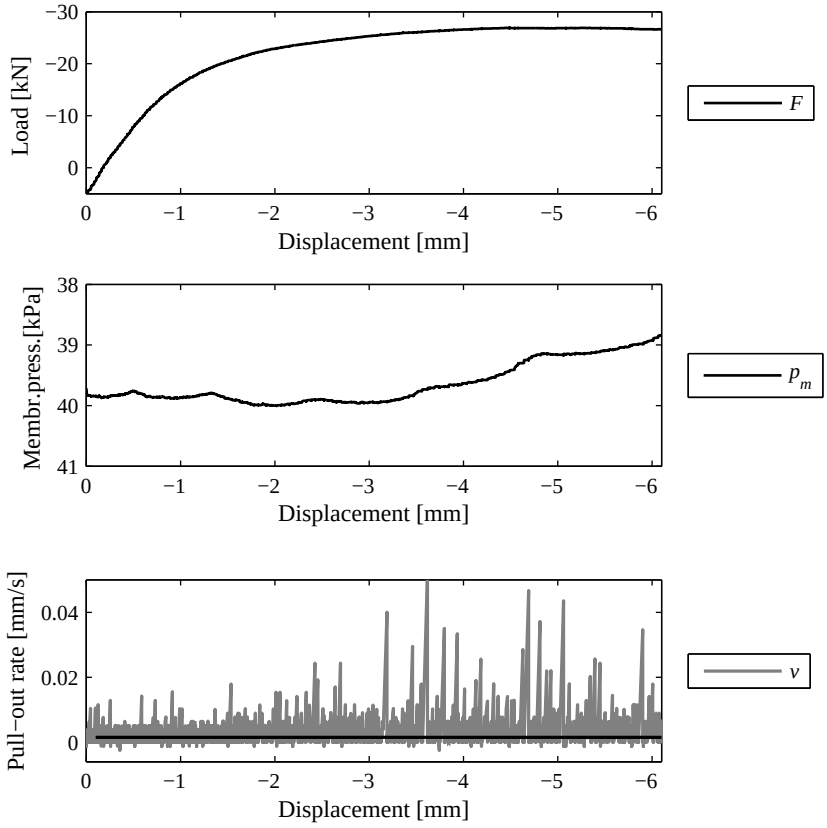

Figure 3.40: Loading 13.02.12.

3.13 Test 13.02.13

Soil properties			Loading			Installation		
D_R	[%]	82.9	F_T	[kN]	-43.2	F_P	[kN]	70.1
σ of D_R	[%]	6.7	w_T	[mm]	-10.7	d_{inst}	[mm]	493.0
γ	[kN/m^3]	19.5	v	[mm/s]	0.002	Membrane pressure		
γ'	[kN/m^3]	9.5				p_m	[kPa]	68

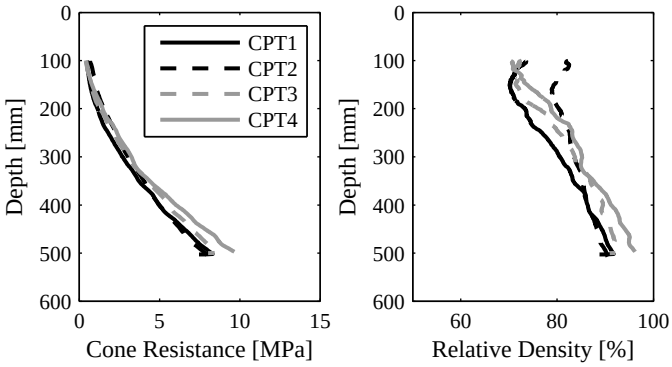

Figure 3.41: CPT testing 13.02.13.

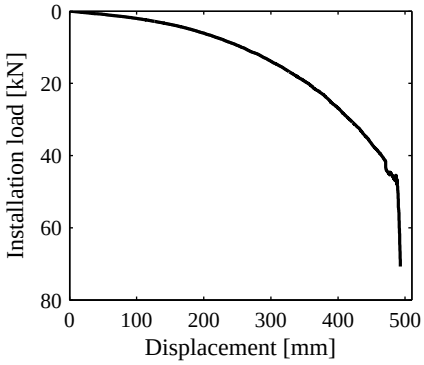

Figure 3.42: Installation 13.02.13.

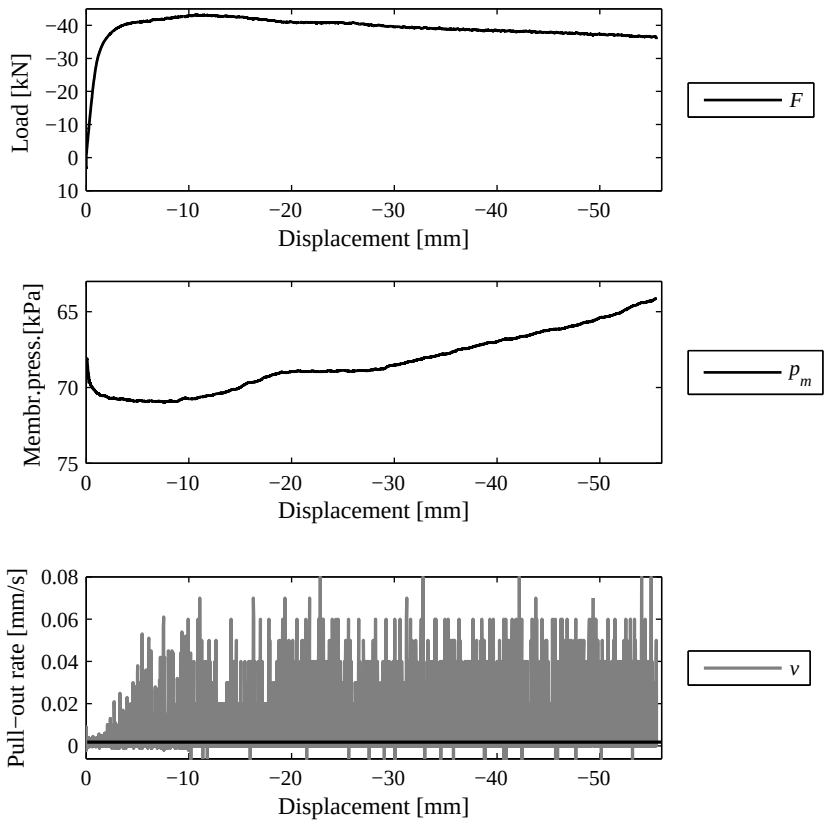

Figure 3.43: Loading 13.02.13.

3.14 Test 13.02.14

Soil properties			Loading			Installation		
D_R	[%]	83.0	F_T	[kN]	-29.8	F_P	[kN]	220.0
σ of D_R	[%]	3.9	w_T	[mm]	-4.5	d_{inst}	[mm]	990.0
γ	[kN/m^3]	19.5	v	[mm/s]	0.001	Membrane pressure		
γ'	[kN/m^3]	9.5				p_m	[kPa]	0

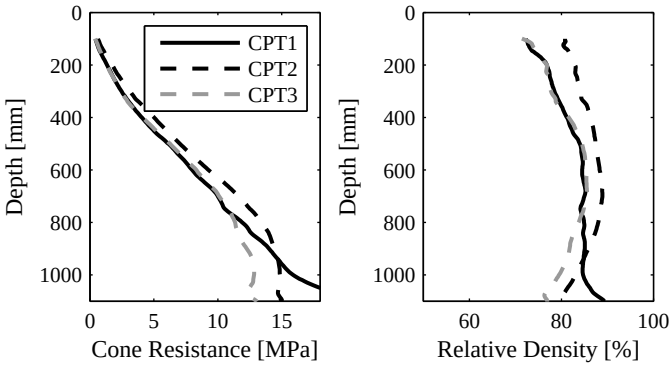

Figure 3.44: CPT testing 13.02.14.

Figure 3.45: Installation 13.02.14.

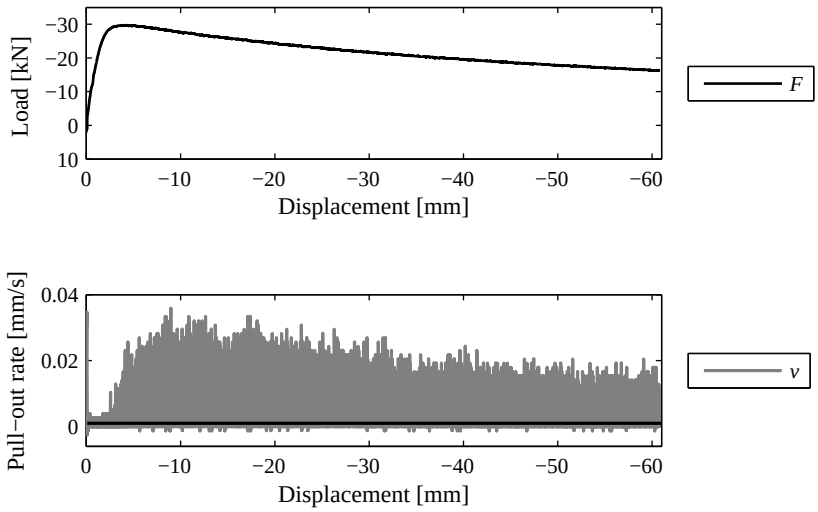

Figure 3.46: Loading 13.02.14.

Comments:
Bucket d/D = 1. Installation was not recorded, but F_P and d_{inst} were visually observed in the computer screen.

3.15 Test 13.02.15

Soil properties			Loading			Installation		
D_R	[%]	85.0	F_T	[kN]	-5.9	F_P	[kN]	73
σ of D_R	[%]	3.8	w_T	[mm]	-5.5	d_{inst}	[mm]	491.0
γ	[kN/m^3]	19.6	v	[mm/s]	0.002	Membrane pressure		
γ'	[kN/m^3]	9.6				p_m	[kPa]	0

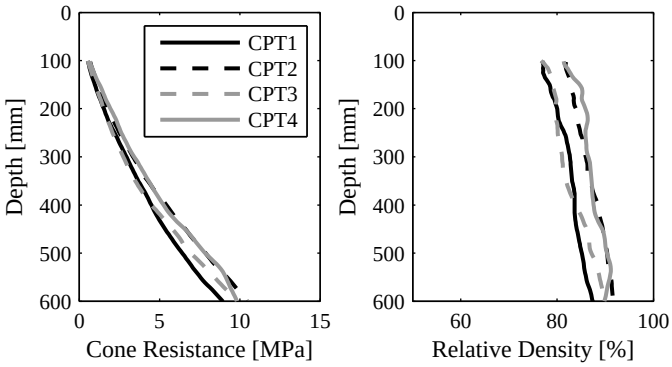

Figure 3.47: CPT testing 13.02.15.

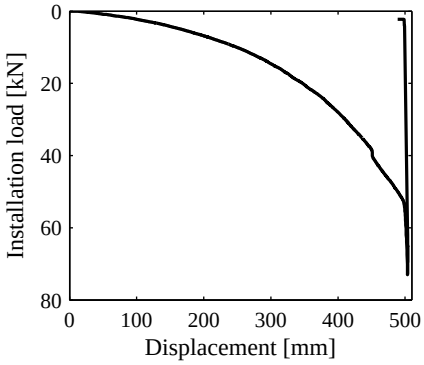

Figure 3.48: Installation 13.02.15.

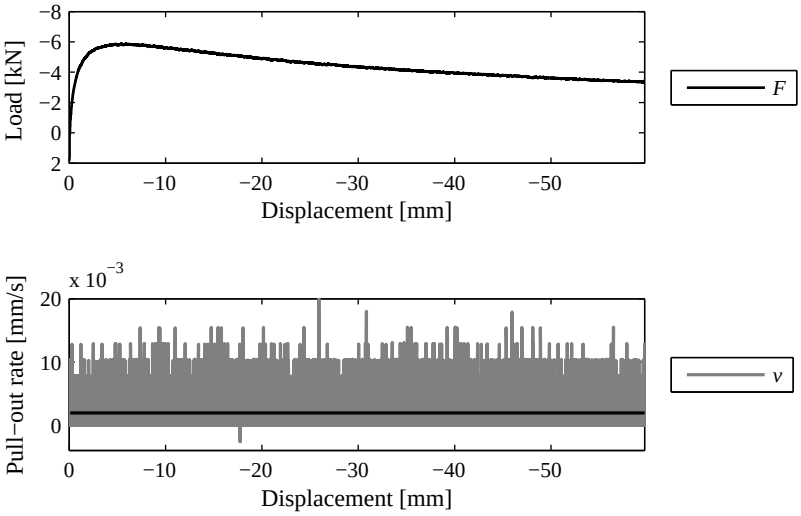

Figure 3.49: Loading 13.02.15.

3.16 Test 13.02.16

Soil properties			Loading			Installation		
D_R	[%]	77.2	F_T	[kN]	-14.9	F_P	[kN]	70.5
σ of D_R	[%]	12.2	w_T	[mm]	-4.8	d_{inst}	[mm]	493.0
γ	[kN/m^3]	19.2	v	[mm/s]	0.002	Membrane pressure		
γ'	[kN/m^3]	9.2				p_m	[kPa]	0

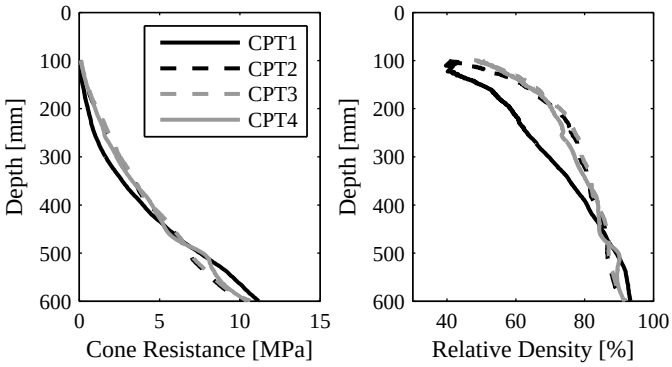

Figure 3.50: CPT testing 13.02.16.

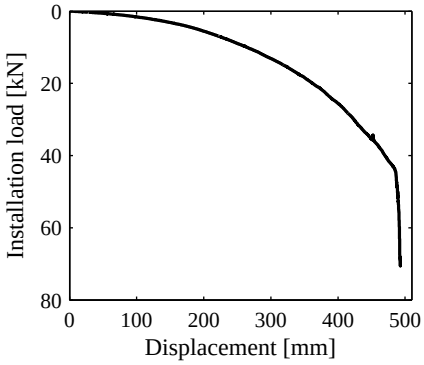

Figure 3.51: Installation 13.02.16.

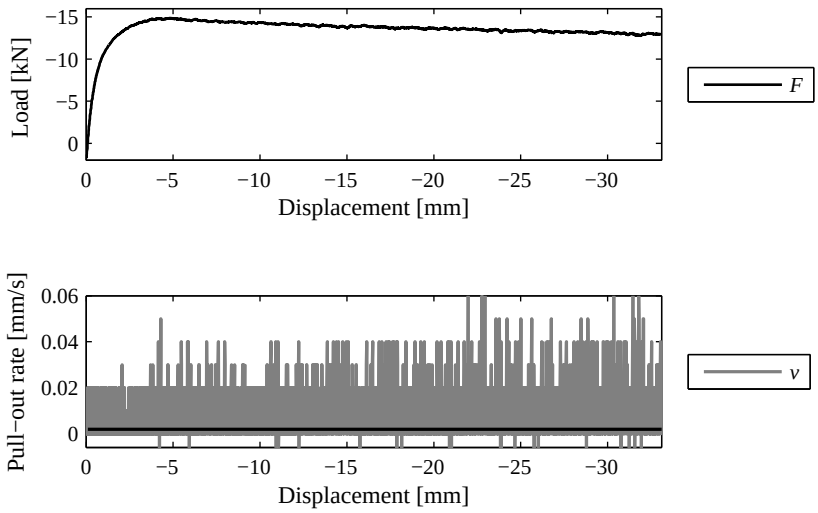

Figure 3.52: Loading 13.02.16.

3.17 Test 13.02.17

Soil properties			Loading			Installation		
D_R	[%]	83.4	F_T	[kN]	-96.3	F_P	[kN]	74.0
σ of D_R	[%]	3.3	w_T	[mm]	-72.2	d_{inst}	[mm]	490.0
γ	[kN/m^3]	19.5	v	[mm/s]	0.002	Membrane pressure		
γ'	[kN/m^3]	9.5				p_m	[kPa]	73

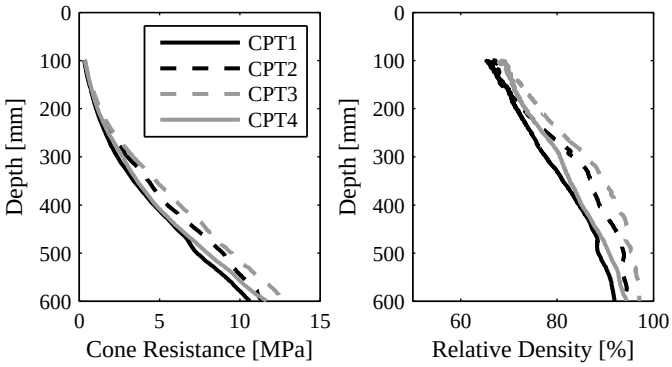

Figure 3.53: CPT testing 13.02.17.

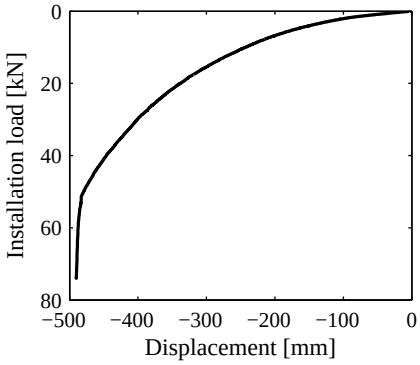

Figure 3.54: Installation 13.02.17.

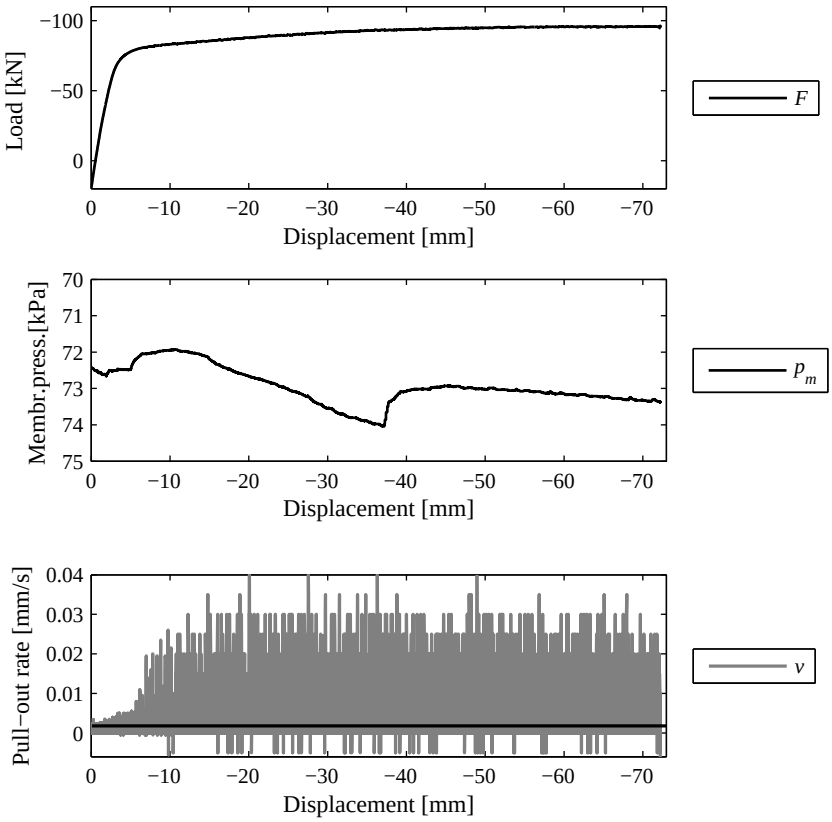

Figure 3.55: Loading 13.02.17.

CHAPTER 4
Test Series 13.03.XX Overview

Series 13.03.XX present cyclic loading tests on a bucket foundation model. This chapter provides the data of tests performed in the large yellow sand box. Bucket model dimensions were: 1.0 m in diameter D, 0.5 mm in skirt length d and 3 mm in skirt thickness t. Figure 3.1 shows the test set-up. Figure 3.3 shows the bucket foundation model. Figure 3.2 shows the positions of the laboratory CPT samplings. Vaitkunaite (2015) described the testing procedure.

Table 4.1: Test series 13.03.XX summary.

p_m, [kPa]	Test No.	Cyclic loading				Post-cyclic load		D_R, [%]	γ', [kN/m^3]
		F_{mean}, [kN]	F_{cyc}, [kN]	w_{cyc}, [mm]	f, [Hz]	F_{Pc}, [kN]	w_{Pc}, [mm]		
0	13.03.01	-2.11	1.02	-0.88	0.10	-5.34	-3.83	78	9.3
0	13.03.02	-2.05	1.93	-1.35	0.10	-5.95	-7.60	77	9.2
0	13.03.03	-2.05	3.85	-63.76	0.10	-	-	79	9.3
0	13.03.05	1.80	3.85	0.15	0.10	-	-	85	9.6
43	13.03.06	11.76	11.38	0.72	0.05	-31.33	-12.35	80	9.3
0	13.03.08	1.91	2.30	0.04	0.05	-5.03	-3.43	77	9.3
41	13.03.09	-13.03	18.37	-67.55	0.10	-	-	(75)	(9.1)
0	13.03.10	-2.05	1.93	-6.23	0.10	-4.74	-0.53	(75)	(9.1)
41	13.03.11	20.12	9.33	-63.81	0.10	-	-	82	9.4
0	13.03.12	-2.05	3.85	-65.80	0.10	-	-	(76)	(9.1)
71	13.03.13	2.01	29.38	0.74	0.05	-	-	82	9.5
70	13.03.14	1.92	29.30	1.25	0.10	-93.26	-28.29	82	9.4
73	13.03.15	-22.39	23.08	0.10	0.10	-93.90	-26.53	87	9.7
71	13.03.16	-51.67	24.49	-75.01	0.10	-	-	79	9.3
71	13.03.17	-50.61	45.78	-81.90	0.10	-	-	81	9.4
0	13.03.19	-0.30	1.66	-0.64	0.10	(-3.49)	-8.66	79	9.3
0	13.03.20	1.80	3.85	0	0.10	-4.85	-1.30	81	9.4
0	13.03.21	0	1.00	-0.29	0.10	-4.86	-4.84	81	9.4

4.1 Test 13.03.01

Soil properties			Loading		
D_R	[%]	77.8	F_{mean}	[kN]	-2.11
σ of D_R	[%]	5.5	F_{cyc}	[kN]	1.02
γ	[kN/m^3]	19.3	w_{cyc}	[mm]	-0.88
γ'	[kN/m^3]	9.3	f	[Hz]	0.10
Installation			f_s	[Hz]	0.04-1
F_P	[kN]	52.4	N	[-]	39,592
d_{inst}	[mm]	486	F_{Pc}	[kN]	-5.34
Membrane pressure			w_{Pc}	[mm]	-3.83
p_m	[kPa]	0	v	[mm/s]	0.002

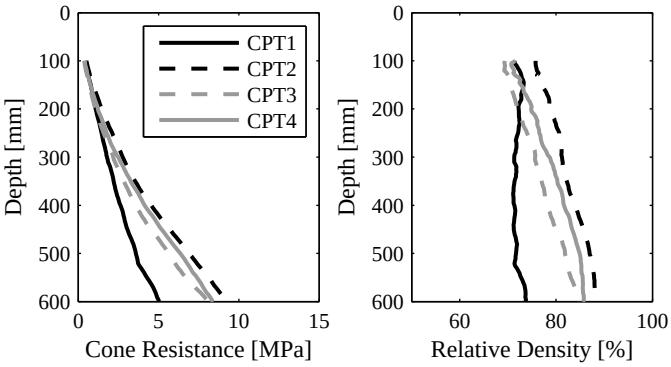

Figure 4.1: CPT testing 13.03.01.

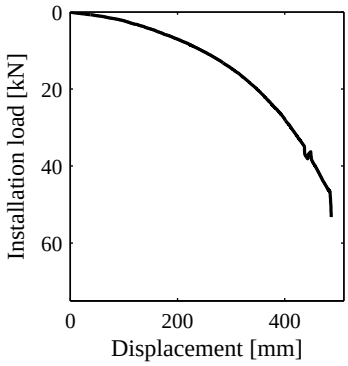

Figure 4.2: Installation 13.03.01.

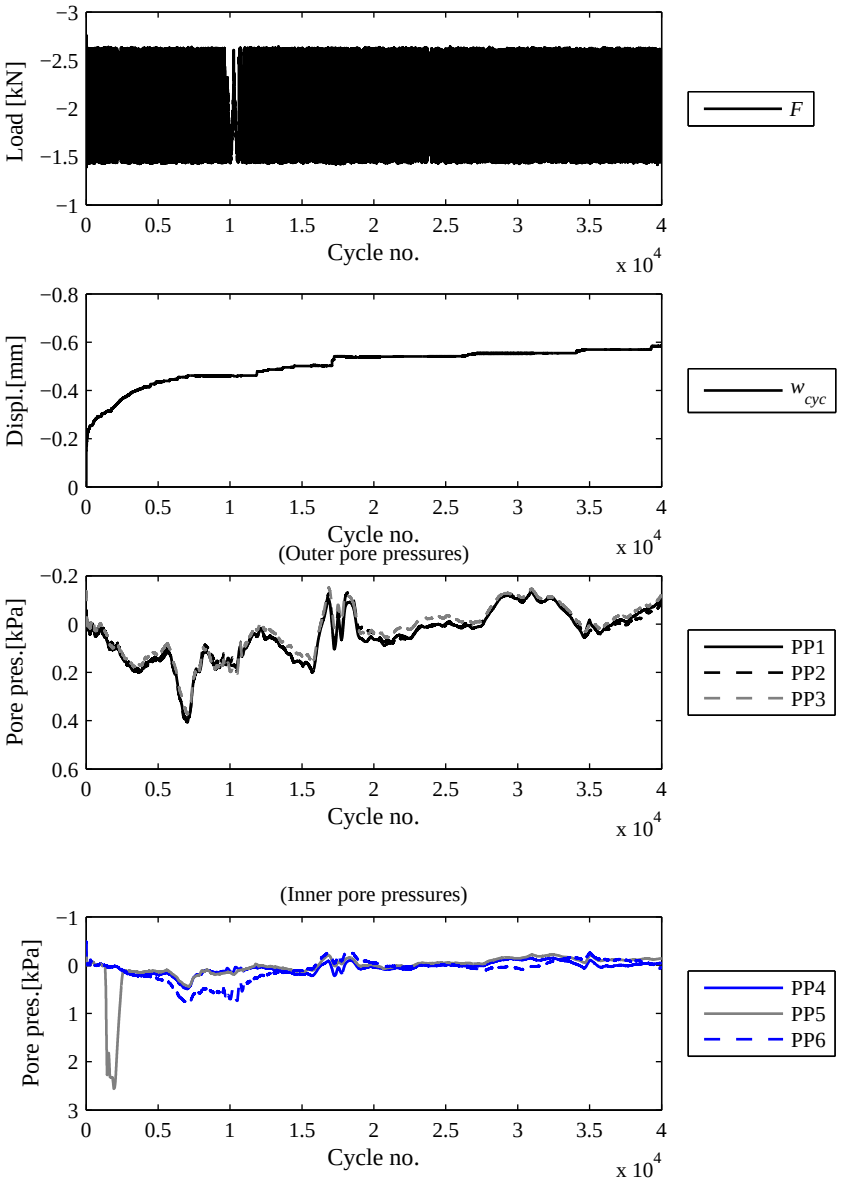

Figure 4.3: Cyclic loading part 13.03.01.

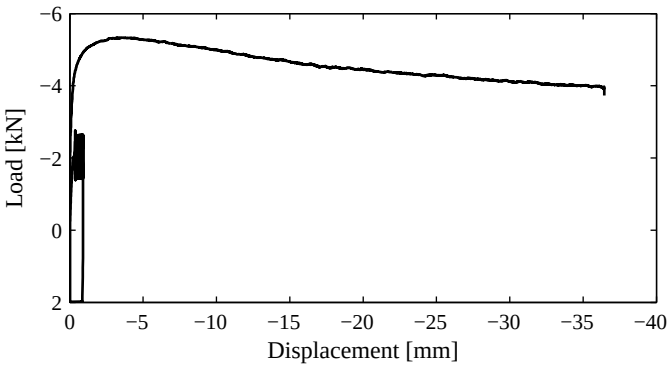

Figure 4.4: Full loading vs. displacement 13.03.01.

Comments:
Problems in data sampling caused by an error in the data acquisition system. After cyclic loading the equipment stopped (unloading). Some hours later, the post-cyclic loading started.

4.2 Test 13.03.02

Soil properties			Loading		
D_R	[%]	76.9	F_{mean}	[kN]	-2.05
σ of D_R	[%]	5.3	F_{cyc}	[kN]	1.93
γ	[kN/m^3]	19.2	w_{cyc}	[mm]	-1.35
γ'	[kN/m^3]	9.2	f	[Hz]	0.10
Installation			f_s	[Hz]	0.05-1
F_P	[kN]	71	N	[-]	38,227
d_{inst}	[mm]	-	F_{Pc}	[kN]	-5.95
Membrane pressure			w_{Pc}	[mm]	-7.60
p_m	[kPa]	0	v	[mm/s]	0.002

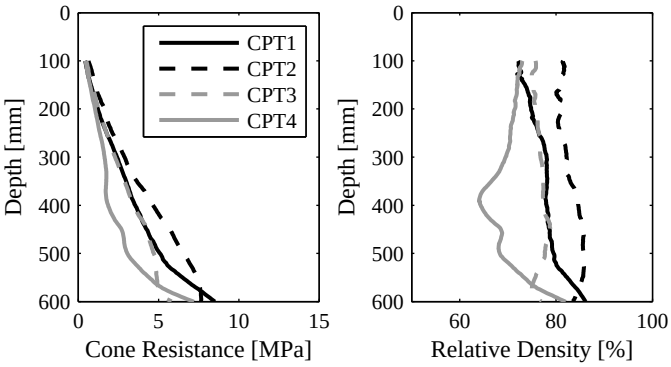

Figure 4.5: CPT testing 13.03.02.

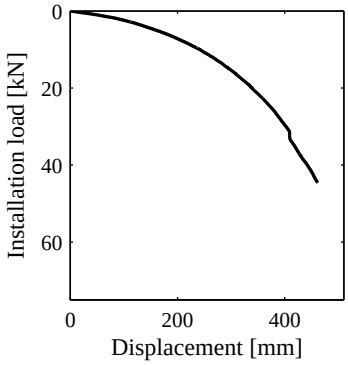

Figure 4.6: Installation 13.03.02.

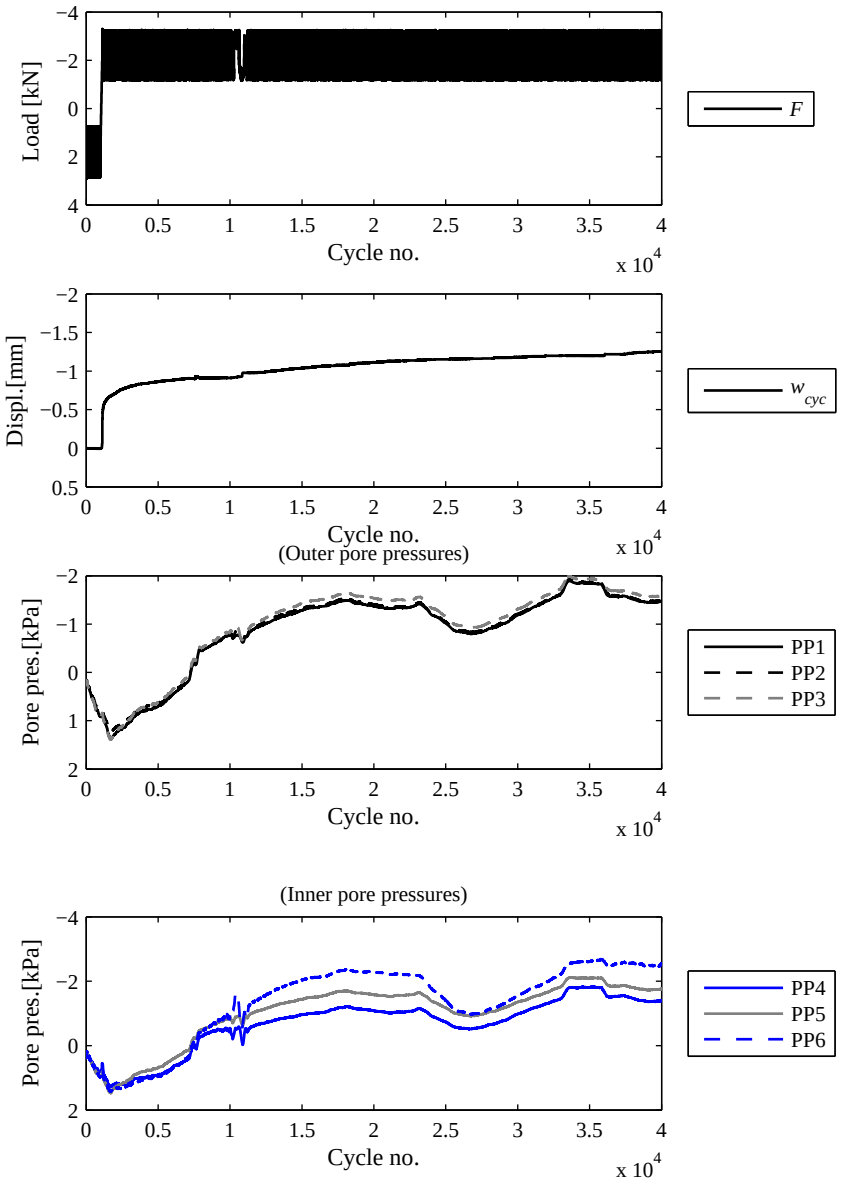

Figure 4.7: Cyclic loading part 13.03.02.

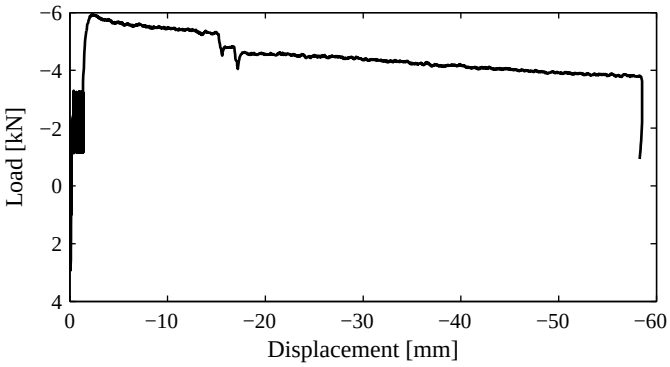

Figure 4.8: Full loading vs. displacement 13.03.02.

Comments:
Installation response is not full, the final pre-load was observed in the computer screen. During the first 950 cycles, the cyclic mean load was +2.05 kN (compressive). Problems in data sampling caused by an error in the data acquisition system.

4.3 Test 13.03.03

Soil properties			Loading		
D_R	[%]	78.7	F_{mean}	[kN]	-2.05
σ of D_R	[%]	4.8	F_{cyc}	[kN]	3.85
γ	[kN/m^3]	19.3	w_{cyc}	[mm]	-63.76
γ'	[kN/m^3]	9.3	f	[Hz]	0.10
Installation			f_s	[Hz]	0.1-1
F_P	[kN]	71	N	[-]	8,100
d_{inst}	[mm]	492	F_{Pc}	[kN]	-
Membrane pressure			w_{Pc}	[mm]	-
p_m	[kPa]	0	v	[mm/s]	-

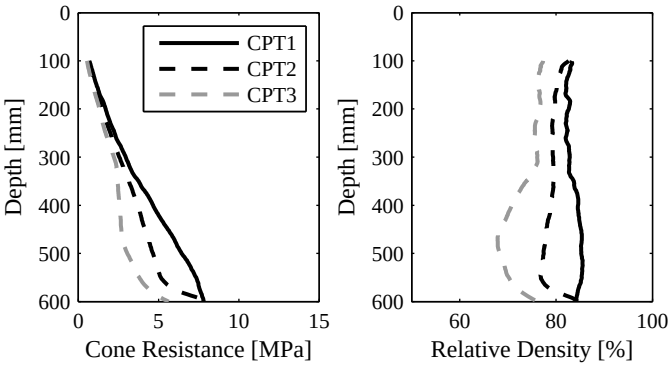

Figure 4.9: CPT testing 13.03.03.

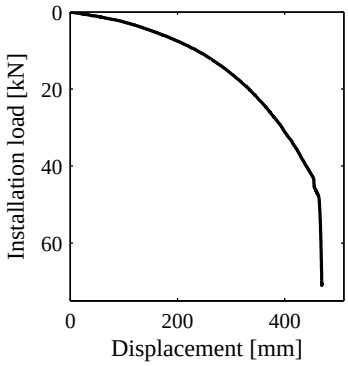

Figure 4.10: Installation 13.03.03.

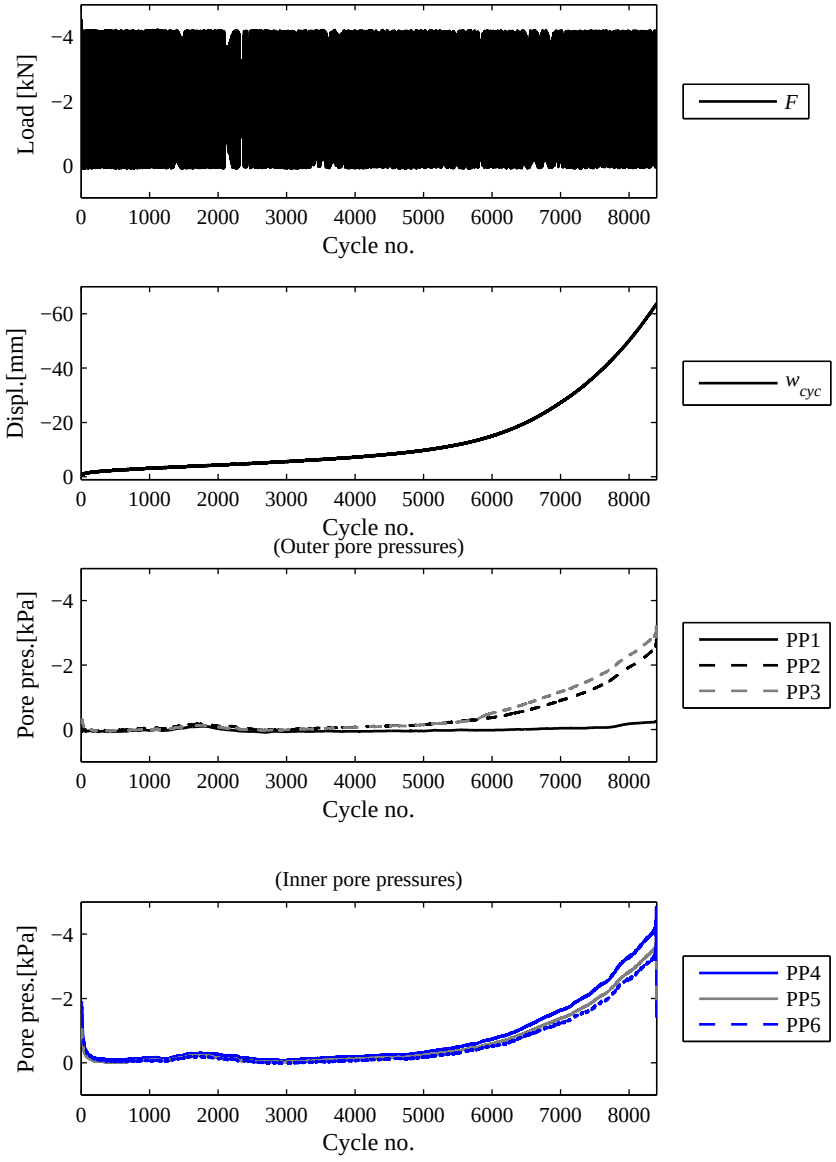

Figure 4.11: Cyclic loading part 13.03.03.

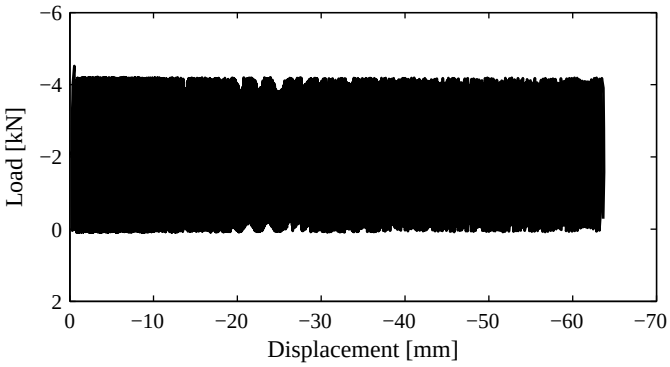

Figure 4.12: Full loading vs. displacement 13.03.03.

Comments:
Problems in data sampling caused by an error in the data acquisition system.

4.4 Test 13.03.05

Soil properties			Loading		
D_R	[%]	85.3	F_{mean}	[kN]	1.80
σ of D_R	[%]	3.8	F_{cyc}	[kN]	3.85
γ	[kN/m^3]	19.6	w_{cyc}	[mm]	0.15
γ'	[kN/m^3]	9.6	f	[Hz]	0.1
Installation			f_s	[Hz]	2
F_P	[kN]	72	N	[-]	28,263
d_{inst}	[mm]	482	F_{Pc}	[kN]	-
Membrane pressure			w_{Pc}	[mm]	-
p_m	[kPa]	0	v	[mm/s]	0.002

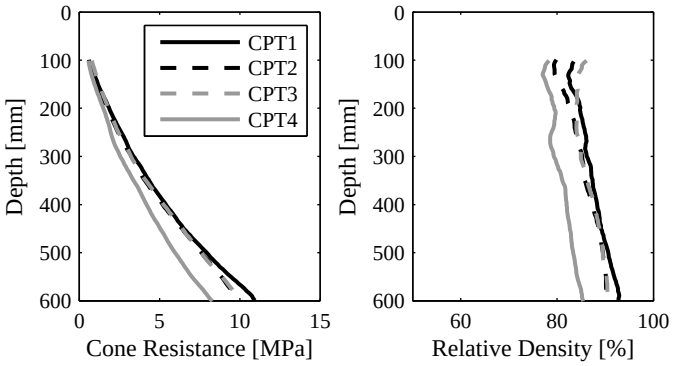

Figure 4.13: CPT testing 13.03.05.

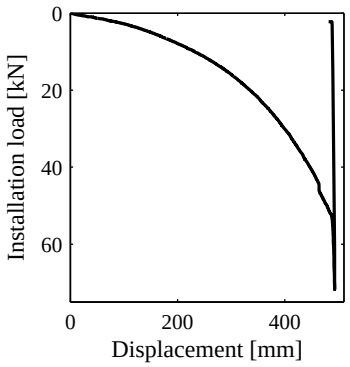

Figure 4.14: Installation 13.03.05.

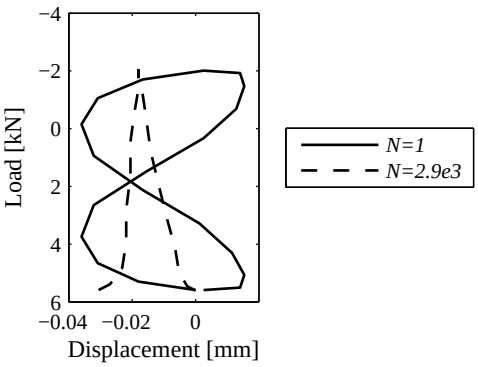

Figure 4.15: Cyclic behaviour 13.03.05.

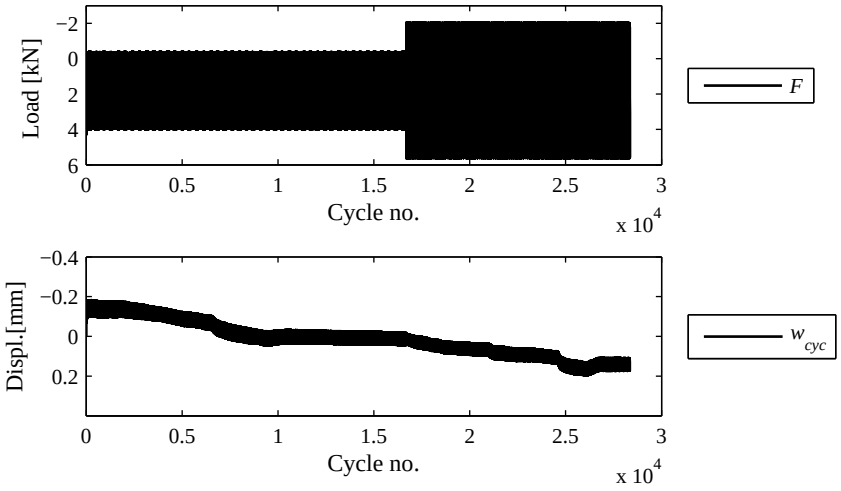

Figure 4.16: Cyclic loading part 13.03.05.

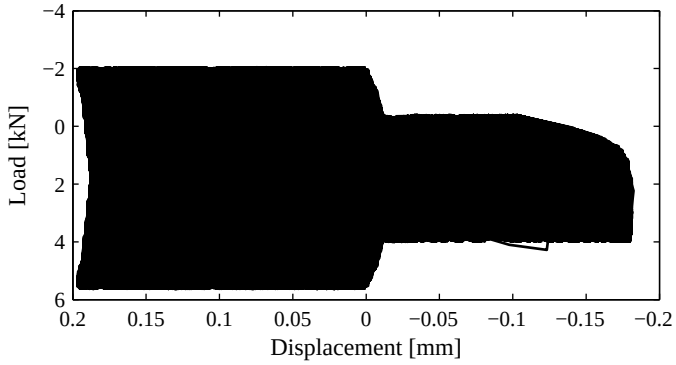

Figure 4.17: Full loading vs. displacement 13.03.05.

Comments:
A sudden pull-out after 28,263 cycles, must be some technical mistake.

4.5 Test 13.03.06

Soil properties			Loading		
D_R	[%]	79.9	F_{mean}	[kN]	11.76
σ of D_R	[%]	4.3	F_{cyc}	[kN]	11.38
γ	[kN/m^3]	19.3	w_{cyc}	[mm]	0.72
γ'	[kN/m^3]	9.3	f	[Hz]	0.05
Installation			f_s	[Hz]	2
F_P	[kN]	70.9	N	[-]	19,900
d_{inst}	[mm]	493	F_{Pc}	[kN]	-31.33
Membrane pressure			w_{Pc}	[mm]	-12.35
p_m	[kPa]	43	v	[mm/s]	0.002

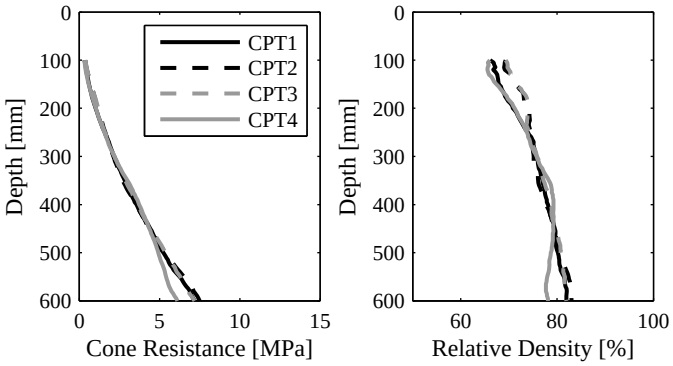

Figure 4.18: CPT testing 13.03.06.

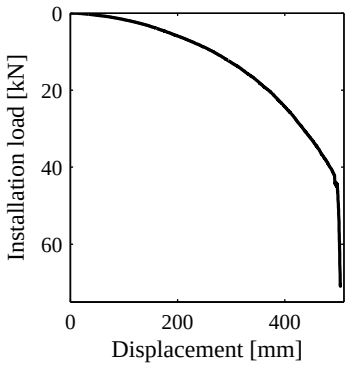

Figure 4.19: Installation 13.03.06.

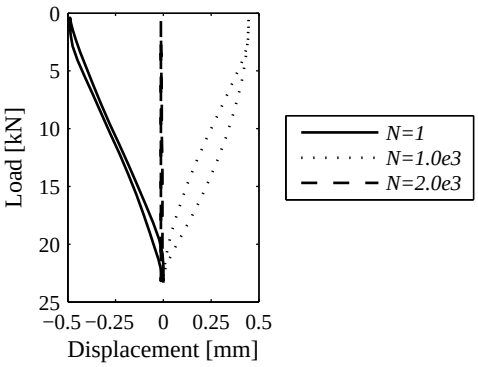

Figure 4.20: Cyclic behaviour 13.03.06.

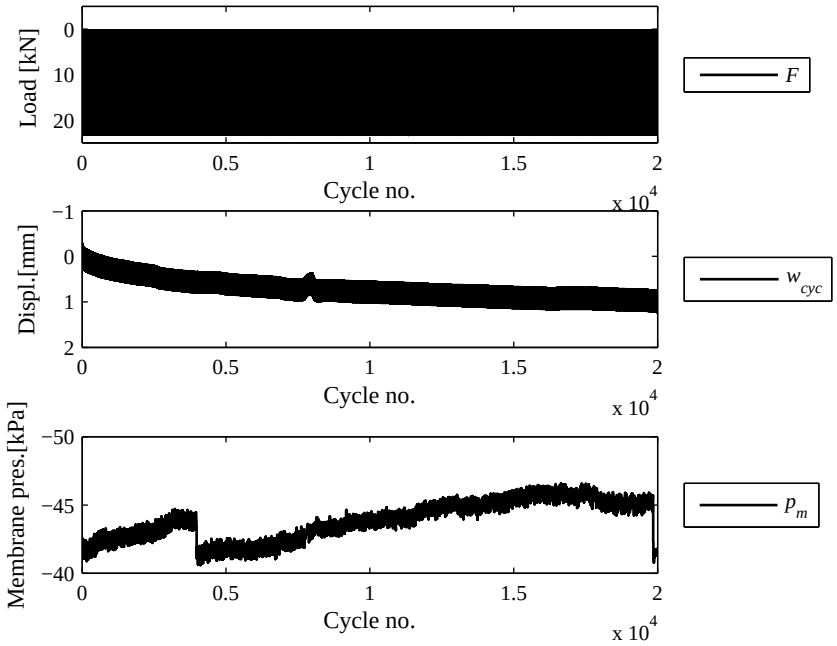

Figure 4.21: Cyclic loading part 13.03.06.

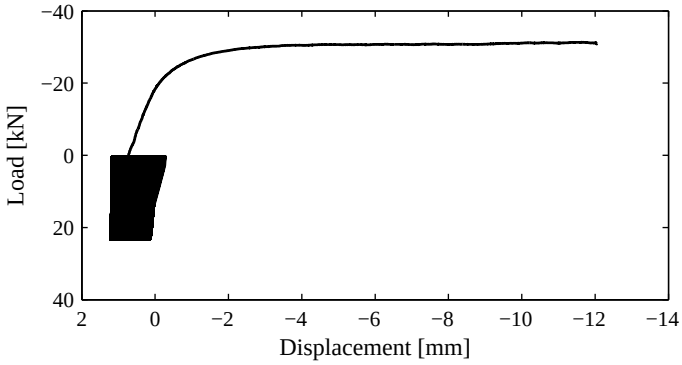

Figure 4.22: Full loading vs. displacement 13.03.06.

4.6 Test 13.03.08

Soil properties			Loading		
D_R	[%]	76.9	F_{mean}	[kN]	1.91
σ of D_R	[%]	8.1	F_{cyc}	[kN]	2.30
γ	[kN/m^3]	19.3	w_{cyc}	[mm]	0.04
γ'	[kN/m^3]	9.3	f	[Hz]	0.05
Installation			f_s	[Hz]	2
F_P	[kN]	70.4	N	[-]	19,629
d_{inst}	[mm]	493	F_{Pc}	[kN]	-5.03
Membrane pressure			w_{Pc}	[mm]	-3.43
p_m	[kPa]	0	v	[mm/s]	0.002

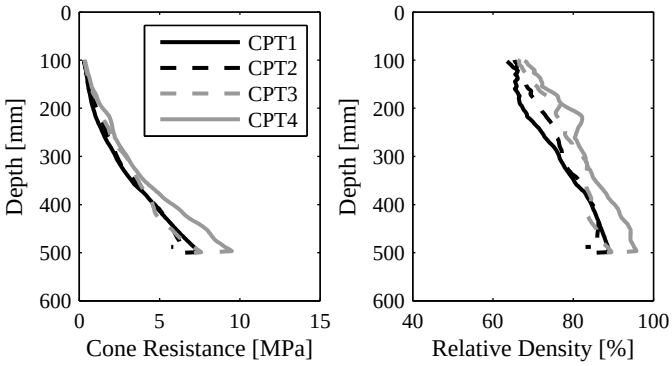

Figure 4.23: CPT testing 13.03.08.

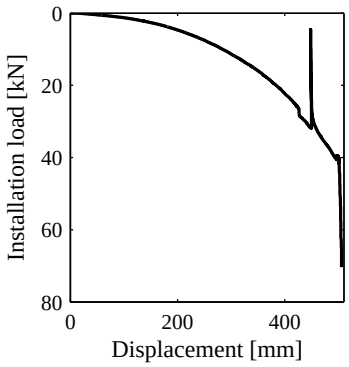

Figure 4.24: Installation 13.03.08.

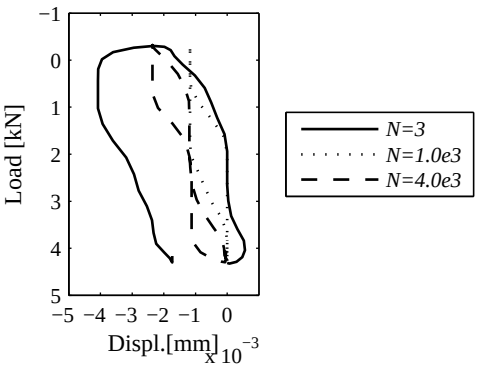

Figure 4.25: Cyclic behaviour 13.03.08.

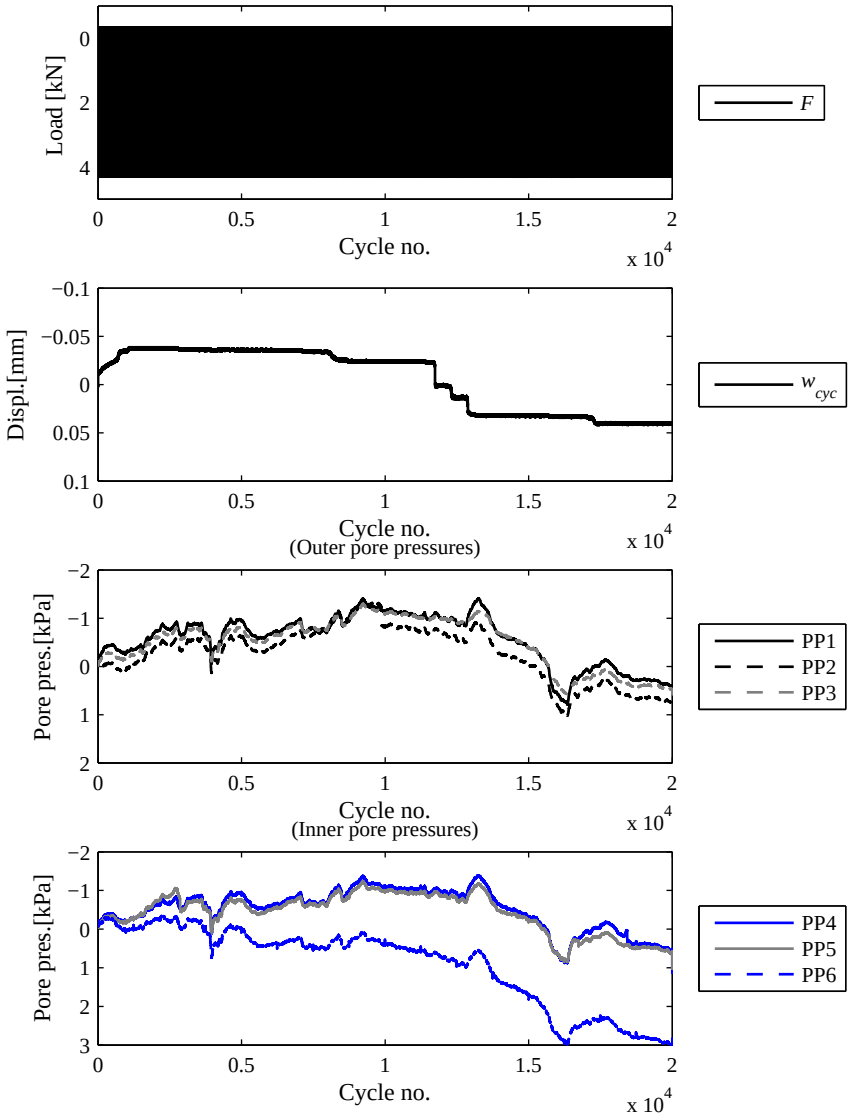

Figure 4.26: Cyclic loading part 13.03.08.

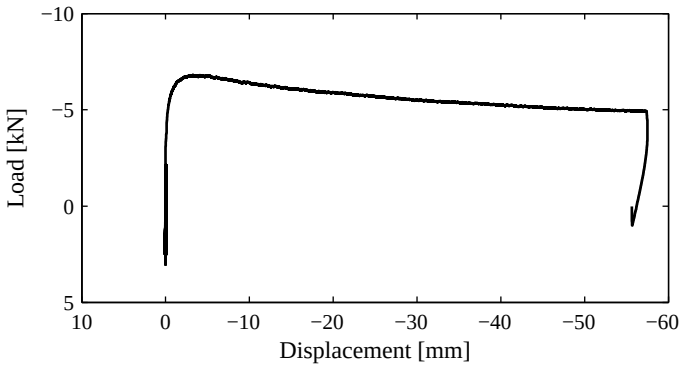

Figure 4.27: Full loading vs. displacement 13.03.08.

Comments:
Problems in data sampling caused by an error in the data acquisition system: load and displacement signals were not taken at the very same moment. Thus, cyclic behaviour cannot be assessed precisely.

4.7 Test 13.03.09

Soil properties			Loading		
D_R	[%]	(75)	F_{mean}	[kN]	-13.03
σ of D_R	[%]	-	F_{cyc}	[kN]	18.37
γ	[kN/m^3]	(19.1)	w_{cyc}	[mm]	-67.55
γ'	[kN/m^3]	(9.1)	f	[Hz]	0.1
Installation			f_s	[Hz]	2
F_P	[kN]	70.6	N	[-]	67
d_{inst}	[mm]	488	F_{Pc}	[kN]	-
Membrane pressure			w_{Pc}	[mm]	-
p_m	[kPa]	41	v	[mm/s]	-

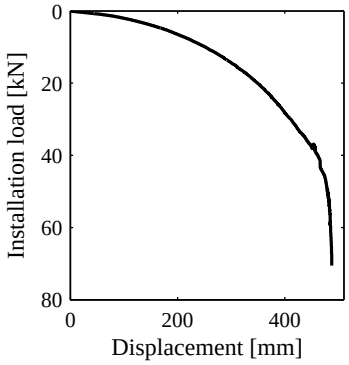

Figure 4.28: Installation 13.03.09.

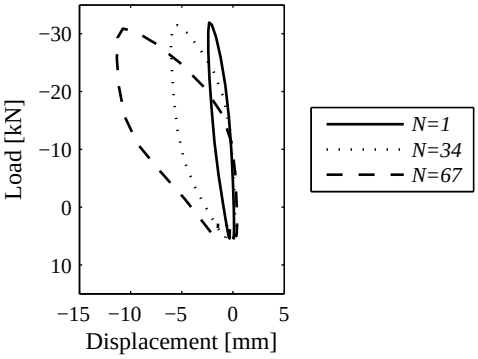

Figure 4.29: Cyclic behaviour 13.03.09.

Comments:
CPT was not performed due to technical problems, approximate properties are estimated from the installation response.

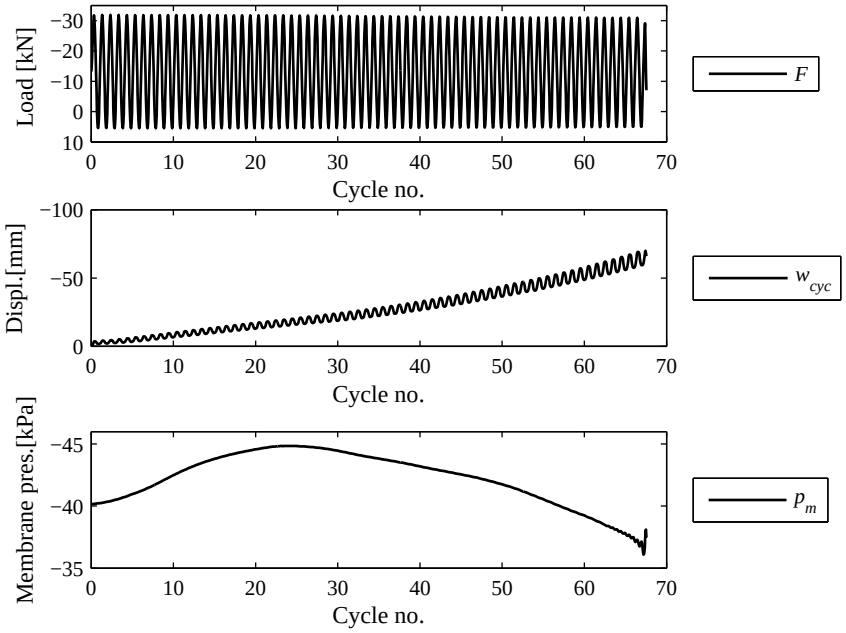

Figure 4.30: Cyclic loading part 13.03.09.

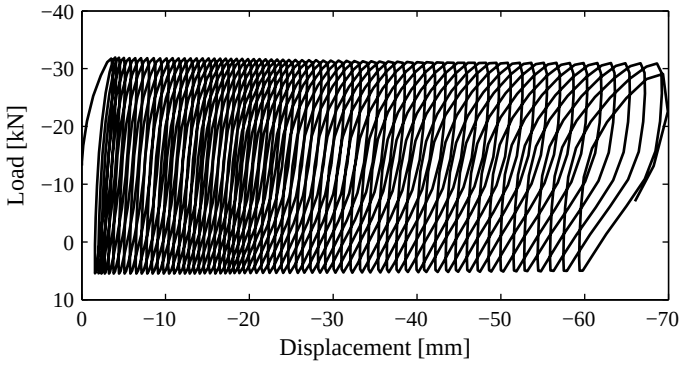

Figure 4.31: Full loading vs. displacement 13.03.09.

4.8 Test 13.03.10

Soil properties			Loading		
D_R	[%]	(75)	F_{mean}	[kN]	-2.05
σ of D_R	[%]	-	F_{cyc}	[kN]	1.93
γ	[kN/m^3]	(19.1)	w_{cyc}	[mm]	-6.23
γ'	[kN/m^3]	(9.1)	f	[Hz]	0.10
Installation			f_s	[Hz]	2
F_P	[kN]	70.5	N	[-]	39,753
d_{inst}	[mm]	495	F_{Pc}	[kN]	-4.74
Membrane pressure			w_{Pc}	[mm]	-0.53
p_m	[kPa]	0	v	[mm/s]	0.002

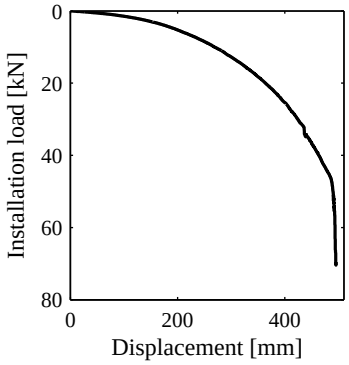

Figure 4.32: Installation 13.03.10.

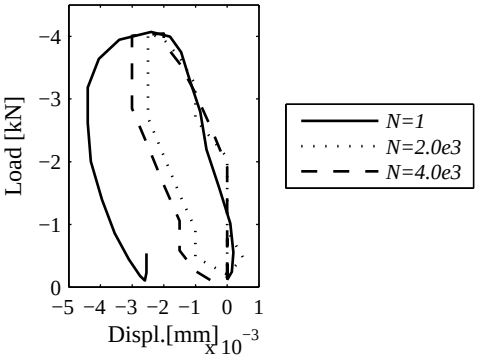

Figure 4.33: Cyclic behaviour 13.03.10.

Comments:
CPT was not performed due to technical problems. Problems in data sampling caused by an error in the data acquisition system: load and displacement signals were not taken at the very same moment. Thus, cyclic behaviour cannot be assessed precisely.

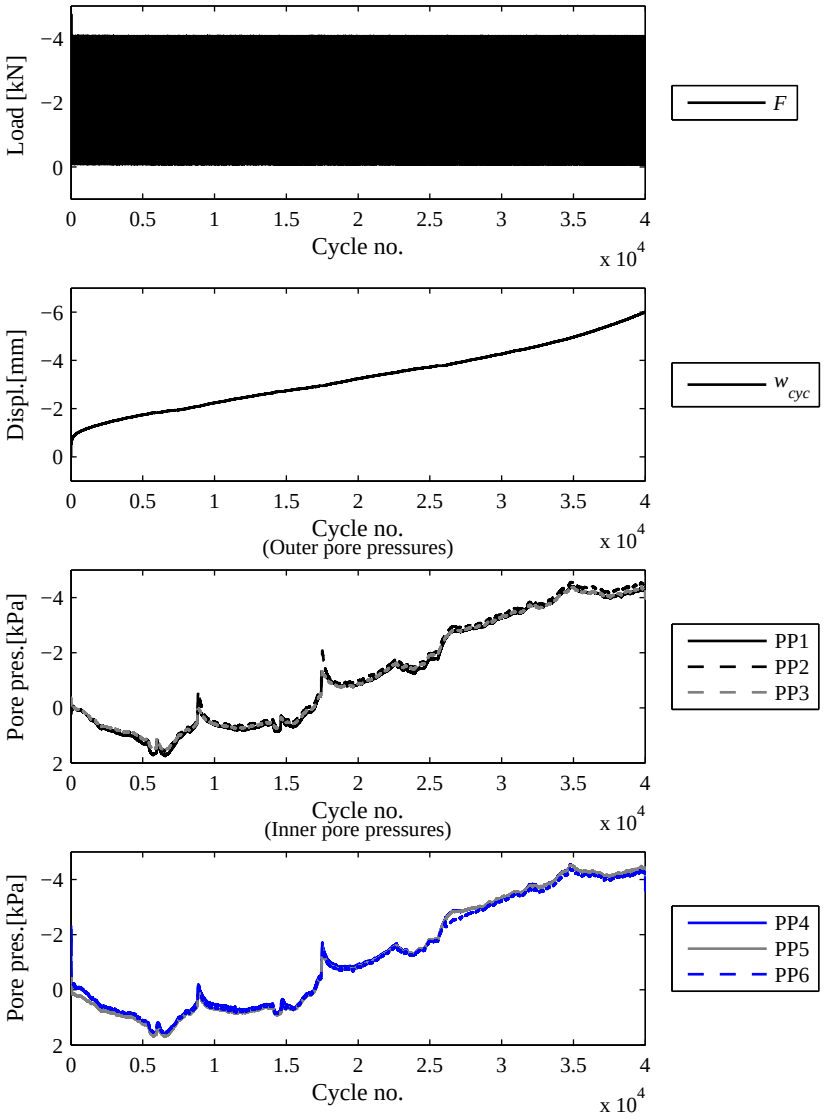

Figure 4.34: Cyclic loading part 13.03.10.

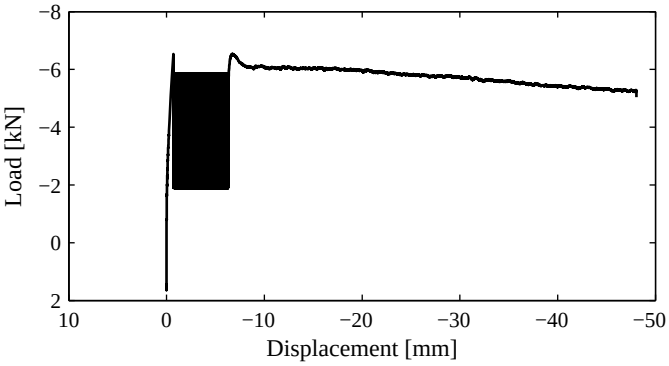

Figure 4.35: Full loading vs. displacement 13.03.10.

4.9 Test 13.03.11

Soil properties			Loading		
D_R	[%]	81.9	F_{mean}	[kN]	20.12
σ of D_R	[%]	8.2	F_{cyc}	[kN]	9.33
γ	[kN/m^3]	19.4	w_{cyc}	[mm]	-63.81
γ'	[kN/m^3]	9.4	f	[Hz]	0.1
Installation			f_s	[Hz]	2
F_P	[kN]	71.2	N	[-]	202
d_{inst}	[mm]	492	F_{Pc}	[kN]	-
Membrane pressure			w_{Pc}	[mm]	-
p_m	[kPa]	41	v	[mm/s]	-

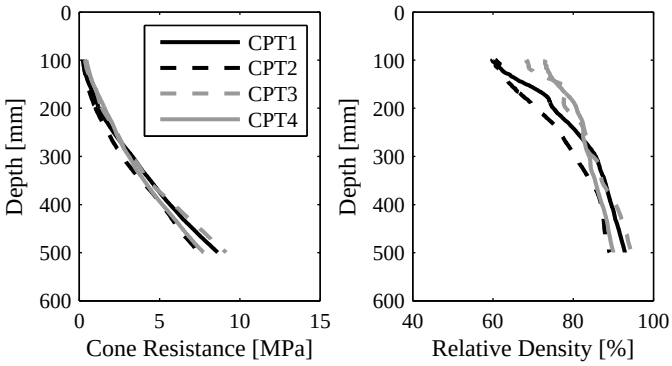

Figure 4.36: CPT testing 13.03.11.

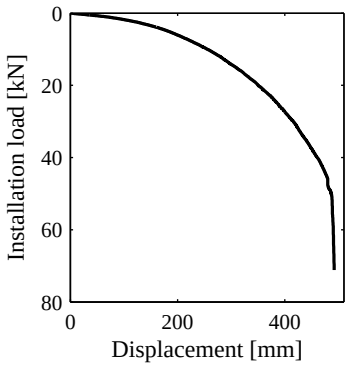

Figure 4.37: Installation 13.03.11.

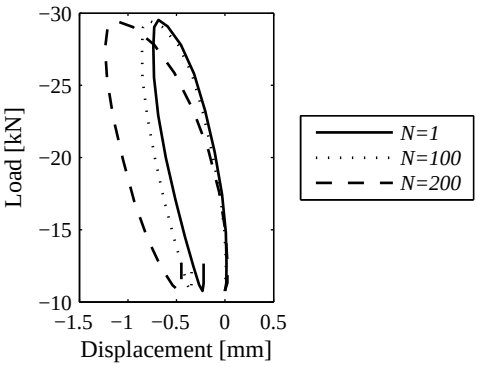

Figure 4.38: Cyclic behaviour 13.03.11.

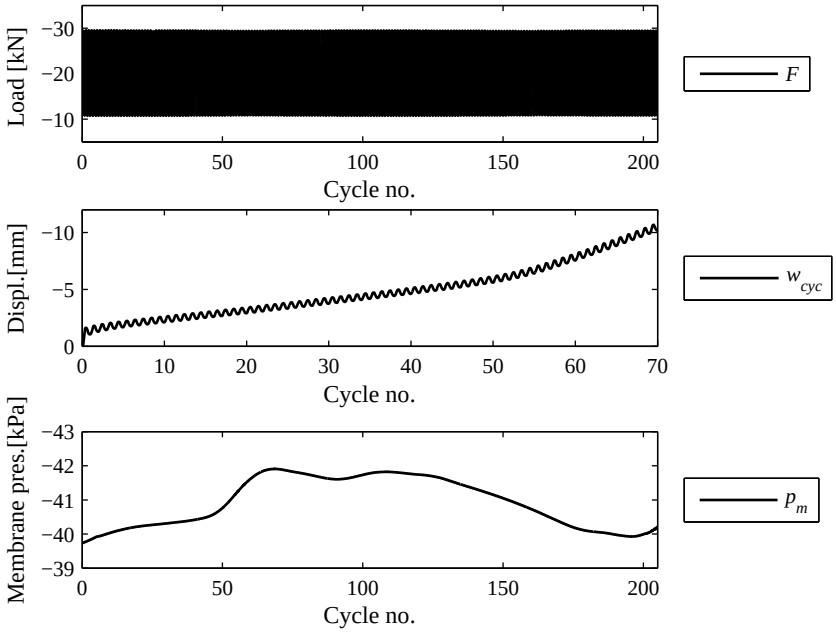

Figure 4.39: Cyclic loading part 13.03.11.

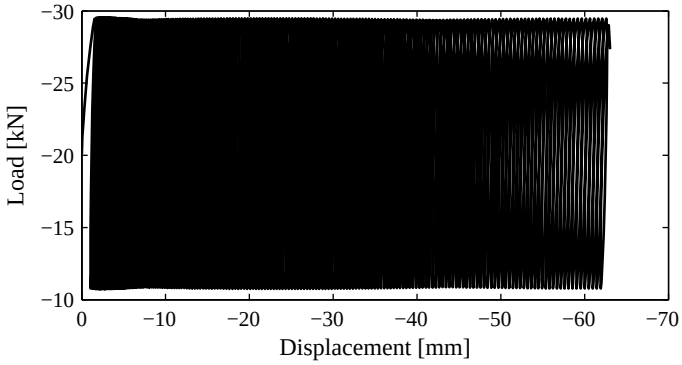

Figure 4.40: Full loading vs. displacement 13.03.11.

4.10 Test 13.03.12

Soil properties			Loading		
D_R	[%]	(76)	F_{mean}	[kN]	-2.05
σ of D_R	[%]	-	F_{cyc}	[kN]	3.85
γ	[kN/m^3]	(19.1)	w_{cyc}	[mm]	-65.80
γ'	[kN/m^3]	(9.1)	f	[Hz]	0.10
Installation			f_s	[Hz]	2
F_P	[kN]	71.2	N	[-]	1,285
d_{inst}	[mm]	499	F_{Pc}	[kN]	-
Membrane pressure			w_{Pc}	[mm]	-
p_m	[kPa]	0	v	[mm/s]	-

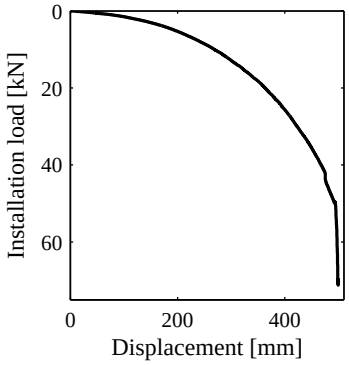

Figure 4.41: Installation 13.03.12.

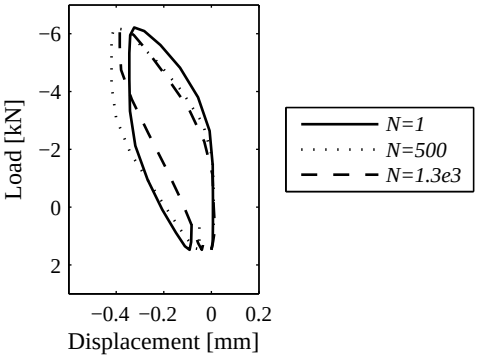

Figure 4.42: Cyclic behaviour 13.03.12.

Comments:
Pore pressure transducer PP2 did not function.

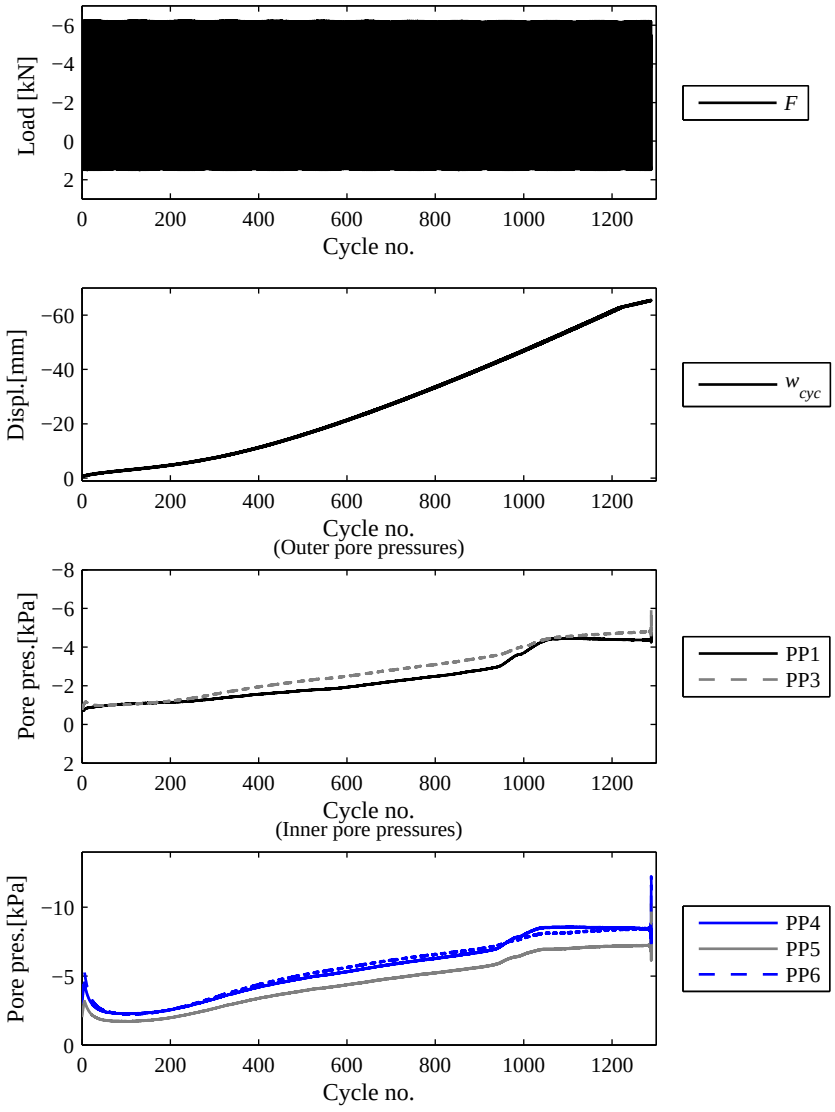

Figure 4.43: Cyclic loading part 13.03.12.

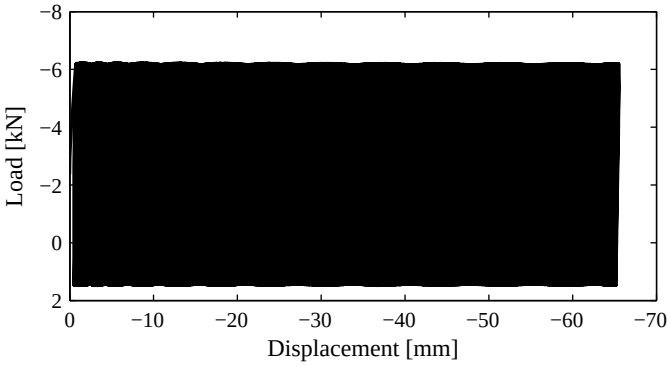

Figure 4.44: Full loading vs. displacement 13.03.12.

4.11 Test 13.03.13

Soil properties			Loading		
D_R	[%]	82.4	F_{mean}	[kN]	2.01
σ of D_R	[%]	11.2	F_{cyc}	[kN]	29.38
γ	[kN/m^3]	19.5	w_{cyc}	[mm]	0.74
γ'	[kN/m^3]	9.5	f	[Hz]	0.05
Installation			f_s	[Hz]	2
F_P	[kN]	74.6	N	[-]	19,970
d_{inst}	[mm]	484	F_{Pc}	[kN]	-
Membrane pressure			w_{Pc}	[mm]	-
p_m	[kPa]	71.4	v	[mm/s]	-

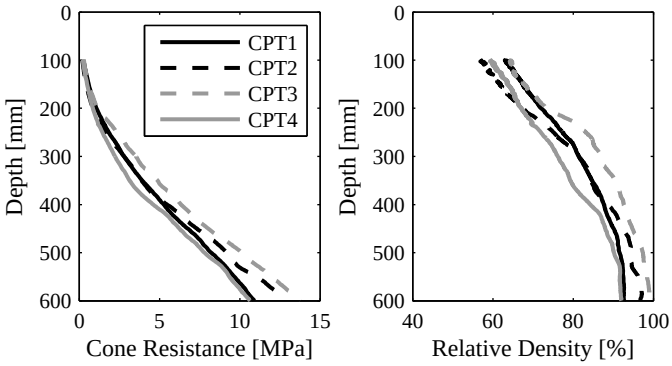

Figure 4.45: CPT testing 13.03.13.

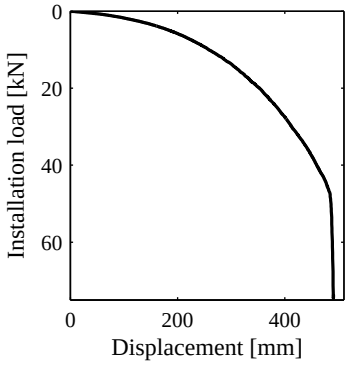

Figure 4.46: Installation 13.03.13.

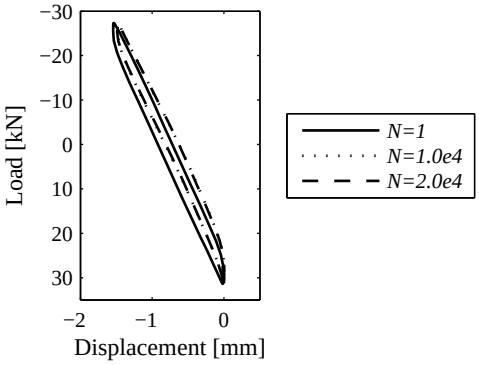

Figure 4.47: Cyclic behaviour 13.03.13.

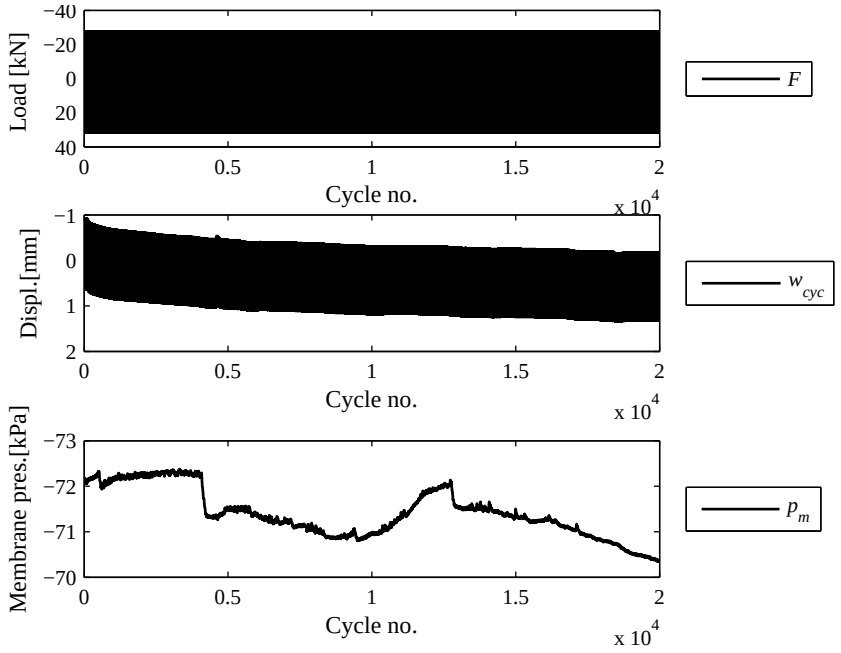

Figure 4.48: Cyclic loading part 13.03.13.

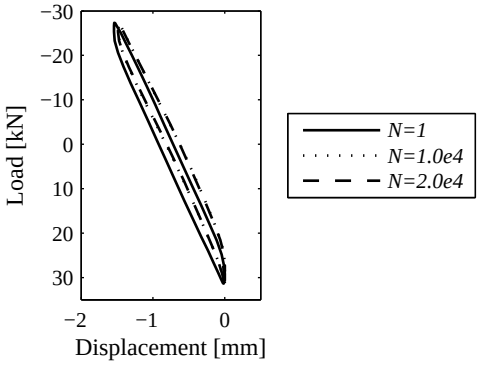

Figure 4.49: Cyclic behaviour 13.03.13.

Comments:
Sand in the first 0.3-0.4 m was less dense than in the deeper layer. Probably, the soil was strongly disturbed due to another testing program in the same sand box and due to membrane pressure applications that create the upward gradient.

4.12 Test 13.03.14

Soil properties			Loading		
D_R	[%]	81.5	F_{mean}	[kN]	1.92
σ of D_R	[%]	9.8	F_{cyc}	[kN]	29.30
γ	[kN/m^3]	19.4	w_{cyc}	[mm]	1.25
γ'	[kN/m^3]	9.4	f	[Hz]	0.10
Installation			f_s	[Hz]	2
F_P	[kN]	73.3	N	[-]	40,867
d_{inst}	[mm]	491	F_{Pc}	[kN]	-93.26
Membrane pressure			w_{Pc}	[mm]	-28.29
p_m	[kPa]	70	v	[mm/s]	0.002

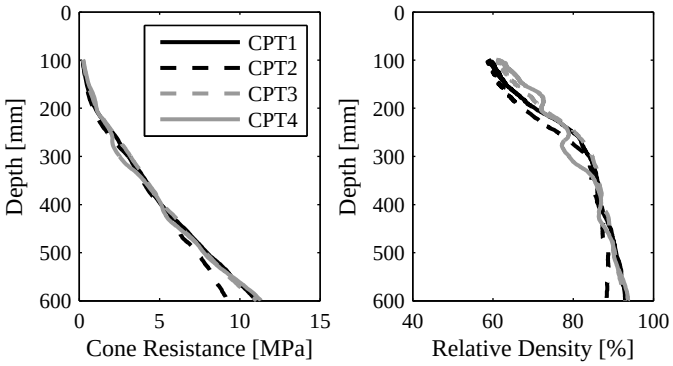

Figure 4.50: CPT testing 13.03.14.

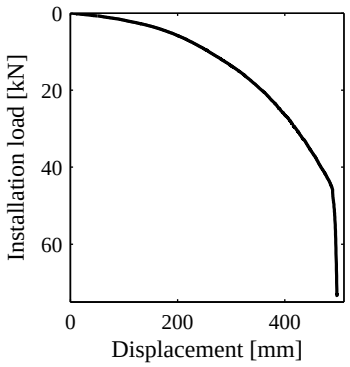

Figure 4.51: Installation 13.03.14.

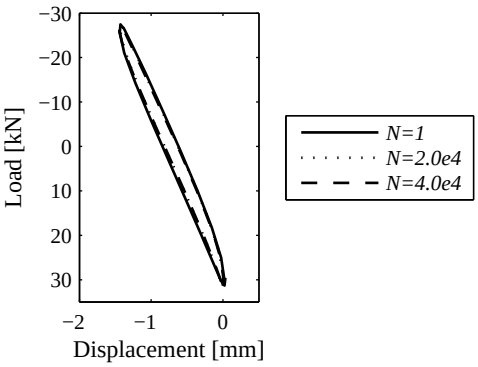

Figure 4.52: Cyclic behaviour 13.03.14.

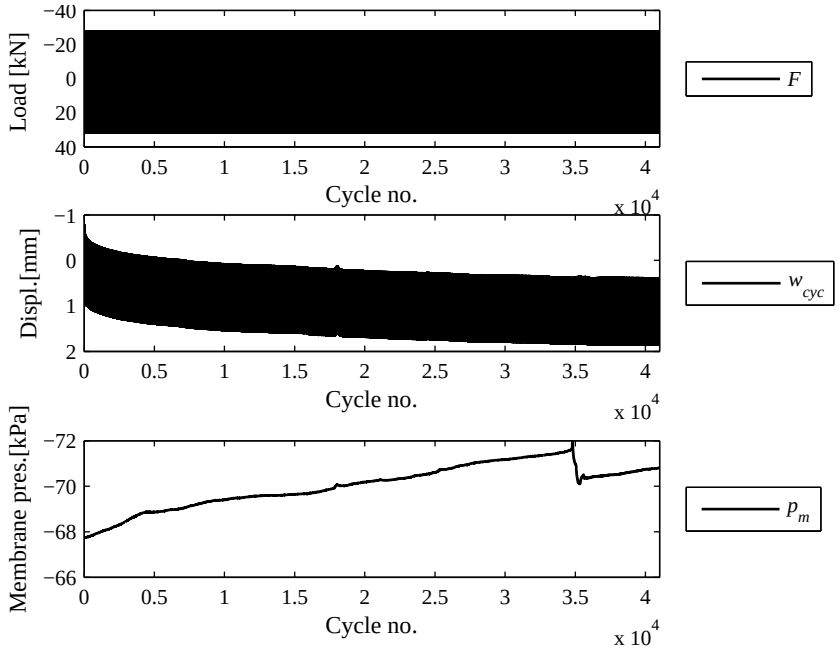

Figure 4.53: Cyclic loading part 13.03.14.

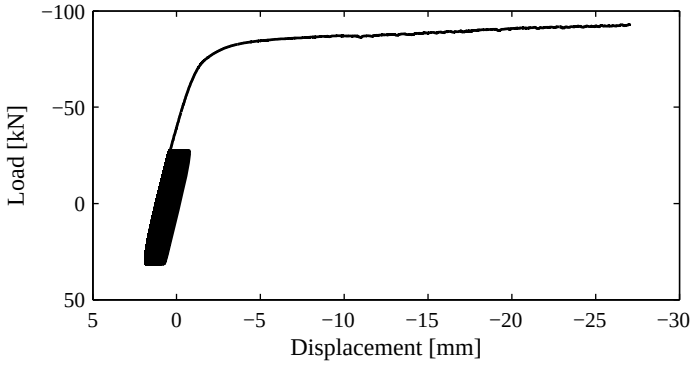

Figure 4.54: Full loading vs. displacement 13.03.14.

Comments:
Sand in the first 0.3-0.4 m was less dense than in the deeper layer. Probably, the soil was strongly disturbed due to another testing program in the same sand box and due to membrane pressure applications that create the upward gradient.

4.13 Test 13.03.15

Soil properties			Loading		
D_R	[%]	87.1	F_{mean}	[kN]	-22.39
σ of D_R	[%]	6.8	F_{cyc}	[kN]	23.08
γ	[kN/m^3]	19.7	w_{cyc}	[mm]	0.10
γ'	[kN/m^3]	9.7	f	[Hz]	0.10
Installation			f_s	[Hz]	2
F_P	[kN]	83.1	N	[-]	31,619
d_{inst}	[mm]	492	F_{Pc}	[kN]	-93.90
Membrane pressure			w_{Pc}	[mm]	-26.53
p_m	[kPa]	73	v	[mm/s]	0.002

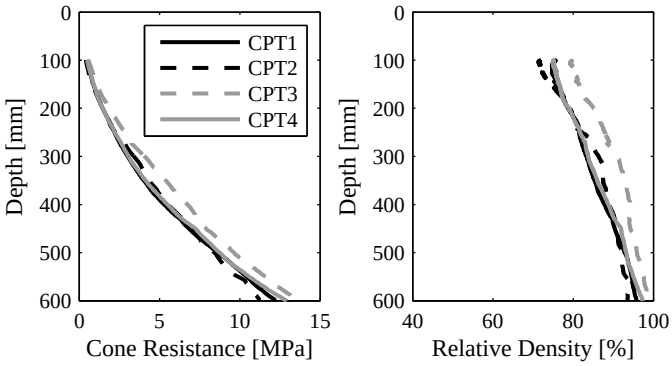

Figure 4.55: CPT testing 13.03.15.

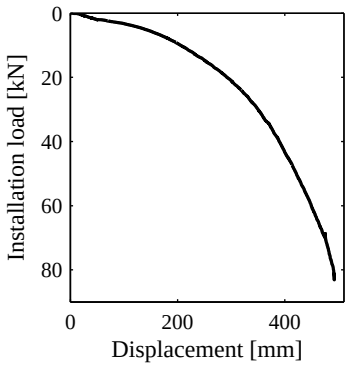

Figure 4.56: Installation 13.03.15.

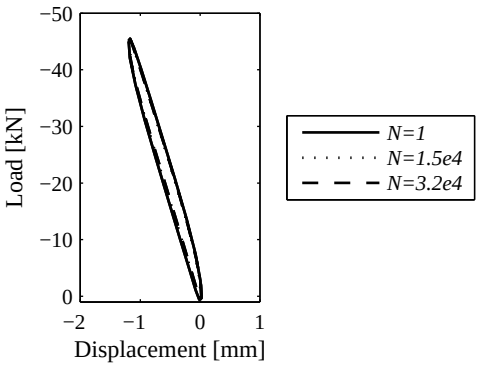

Figure 4.57: Cyclic behaviour 13.03.15.

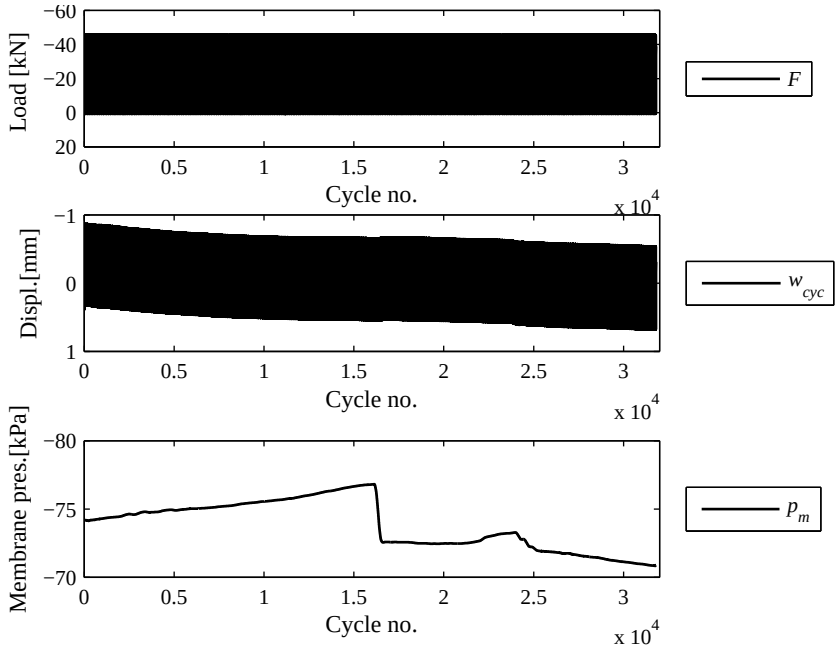

Figure 4.58: Cyclic loading part 13.03.15.

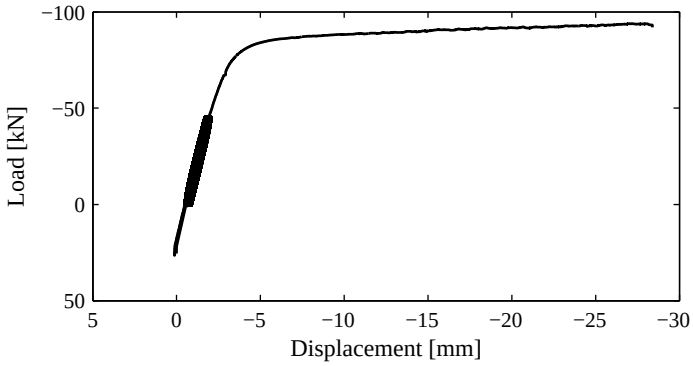

Figure 4.59: Full loading vs. displacement 13.03.15.

4.14 Test 13.03.16

Soil properties			Loading		
D_R	[%]	79.3	F_{mean}	[kN]	-51.67
σ of D_R	[%]	10.1	F_{cyc}	[kN]	24.49
γ	[kN/m^3]	19.3	w_{cyc}	[mm]	-75.01
γ'	[kN/m^3]	9.3	f	[Hz]	0.10
Installation			f_s	[Hz]	2
F_P	[kN]	75.7	N	[-]	19,081
d_{inst}	[mm]	489	F_{Pc}	[kN]	-
Membrane pressure			w_{Pc}	[mm]	-
p_m	[kPa]	71	v	[mm/s]	-

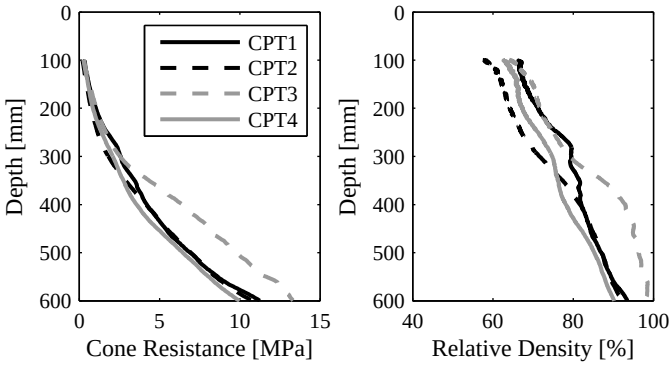

Figure 4.60: CPT testing 13.03.16.

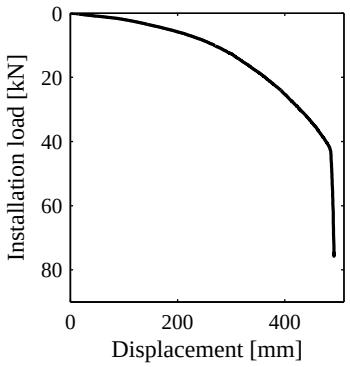

Figure 4.61: Installation 13.03.16.

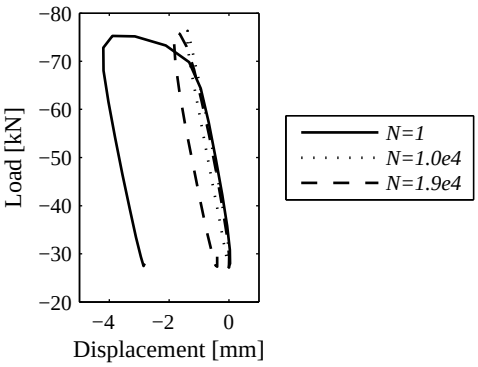

Figure 4.62: Cyclic behaviour 13.03.16.

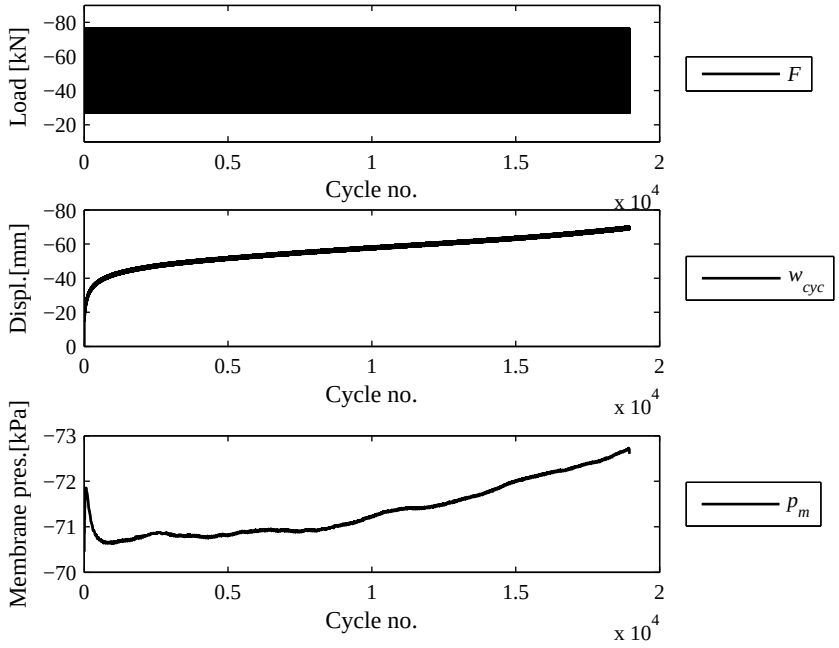

Figure 4.63: Cyclic loading part 13.03.16.

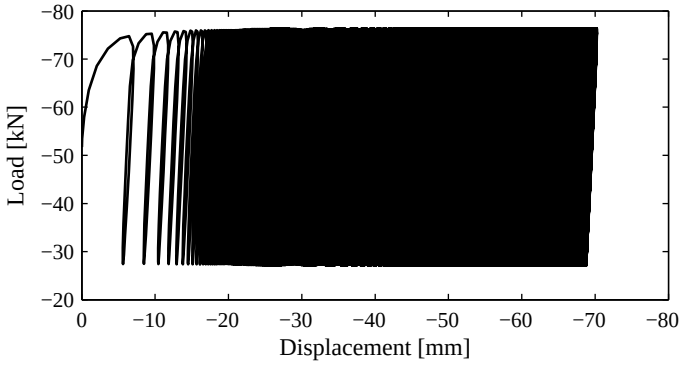

Figure 4.64: Full loading vs. displacement 13.03.16.

Comments:
Sand in the first 0.3-0.4 m was less dense than in the deeper layer. Probably, the soil was strongly disturbed due to another testing program in the same sand box and due to membrane pressure applications that create the upward gradient.

4.15 Test 13.03.17

Soil properties			Loading		
D_R	[%]	81.2	F_{mean}	[kN]	-50.61
σ of D_R	[%]	7.8	F_{cyc}	[kN]	45.78
γ	[kN/m^3]	19.4	w_{cyc}	[mm]	-81.90
γ'	[kN/m^3]	9.4	f	[Hz]	0.10
Installation			f_s	[Hz]	2
F_P	[kN]	74	N	[-]	5
d_{inst}	[mm]	489	F_{Pc}	[kN]	-
Membrane pressure			w_{Pc}	[mm]	-
p_m	[kPa]	71	v	[mm/s]	-

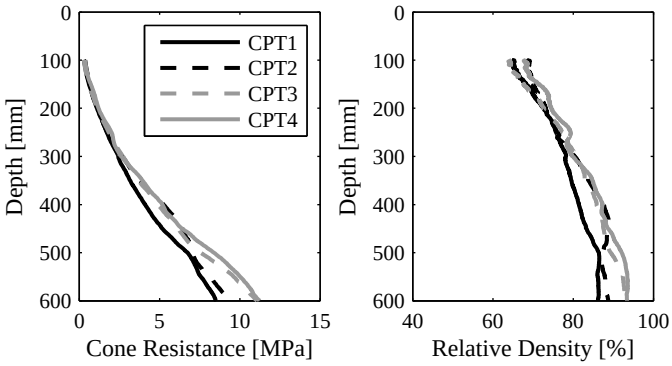

Figure 4.65: CPT testing 13.03.17.

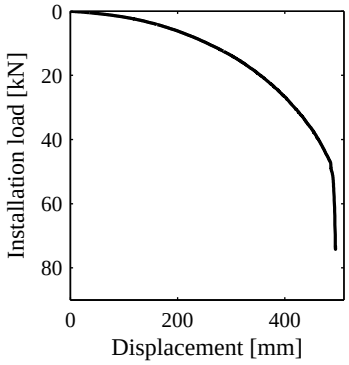

Figure 4.66: Installation 13.03.17.

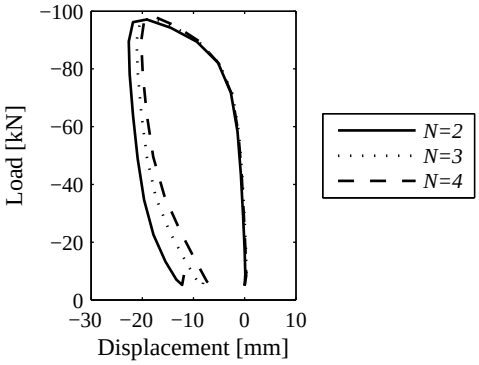

Figure 4.67: Cyclic behaviour 13.03.17.

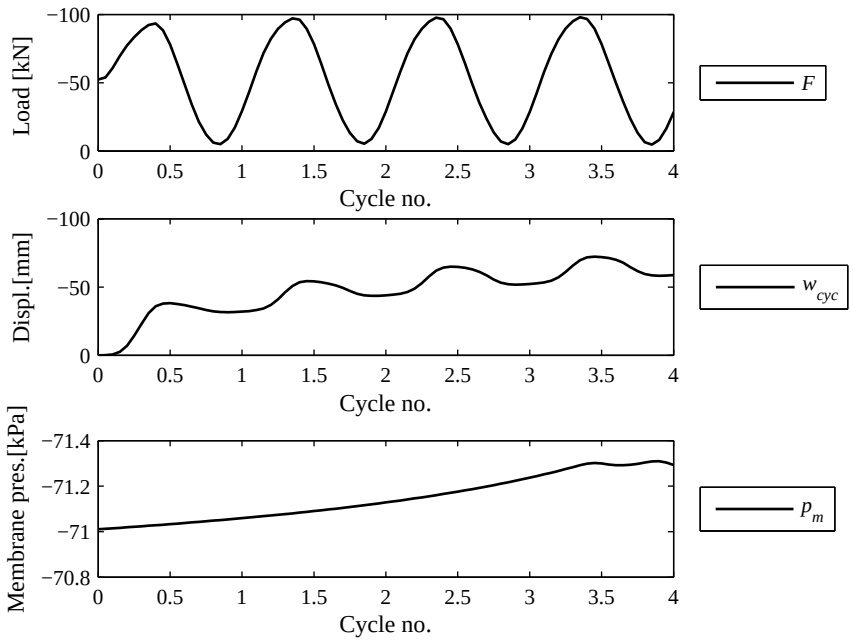

Figure 4.68: Cyclic loading part 13.03.17.

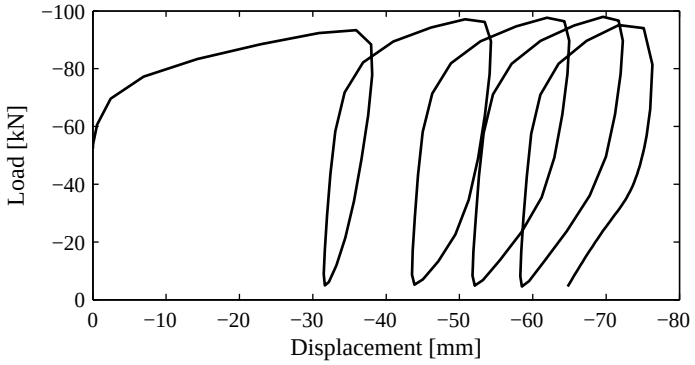

Figure 4.69: Full loading vs. displacement 13.03.17.

Comments:
Sand in the first 0.3-0.4 m was less dense than in the deeper layer. Probably, the soil was strongly disturbed due to another testing program in the same sand box and due to membrane pressure applications that create the upward gradient.

4.16 Test 13.03.19

Soil properties			Loading		
D_R	[%]	79.0	F_{mean}	[kN]	-0.30
σ of D_R	[%]	8.8	F_{cyc}	[kN]	1.66
γ	[kN/m^3]	19.3	w_{cyc}	[mm]	-0.64
γ'	[kN/m^3]	9.3	f	[Hz]	0.10
Installation			f_s	[Hz]	2
F_P	[kN]	(72.5)	N	[-]	39,729
d_{inst}	[mm]	(488)	F_{Pc}	[kN]	(-3.49)
Membrane pressure			w_{Pc}	[mm]	-8.66
p_m	[kPa]	0	v	[mm/s]	0.002

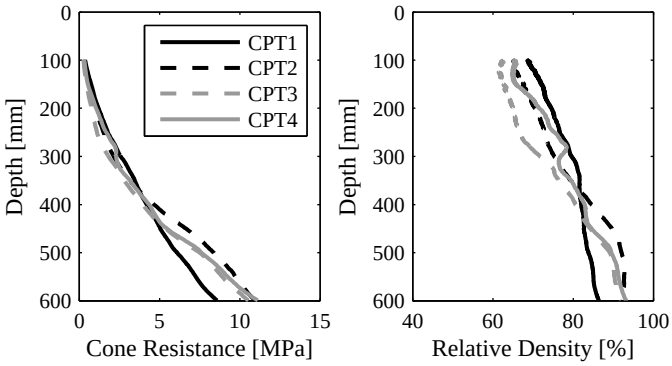

Figure 4.70: CPT testing 13.03.19.

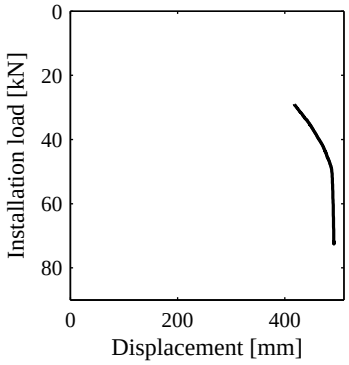

Figure 4.71: Installation 13.03.19.

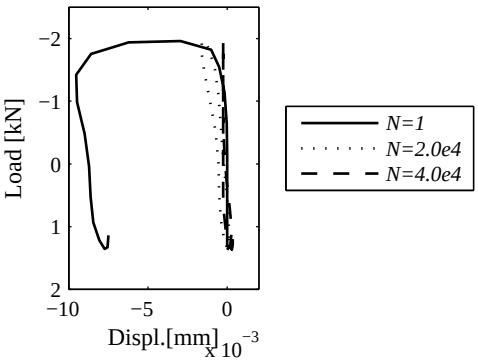

Figure 4.72: Cyclic behaviour 13.03.19.

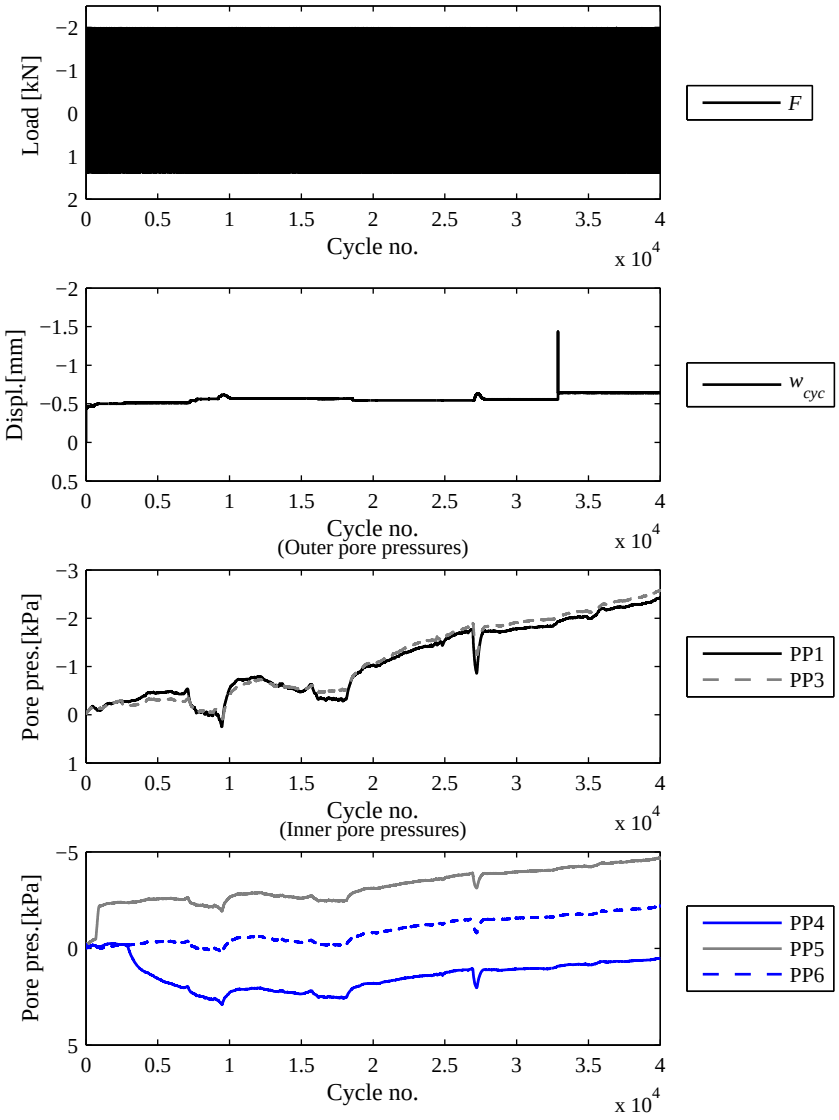

Figure 4.73: Cyclic loading part 13.03.19.

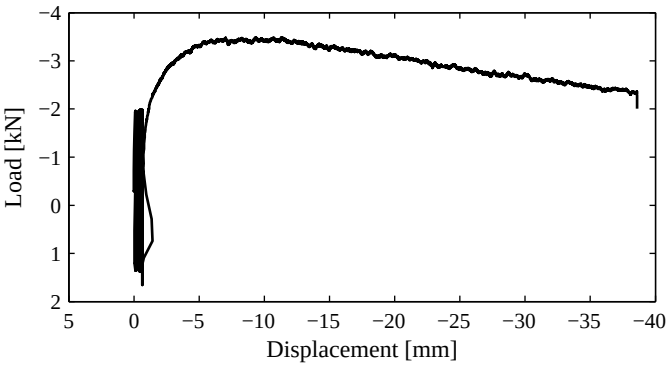

Figure 4.74: Full loading vs. displacement 13.03.19.

Comments:
Only the last part of installation was recorded. Problems in data sampling caused by an error in the data acquisition system: load and displacement signals were not taken at the very same moment. Thus, cyclic behaviour cannot be assessed precisely. Sand in the first 0.3-0.4 m was less dense than in the deeper layer. Probably, the soil was strongly disturbed due to another testing program in the same sand box and due to membrane pressure applications that create the upward gradient. Post-cyclic pull-out should be ignored, because it was interrupted at the very beginning. Possible problems with pore pressure transducer calibration (settings in the computer program).

4.17 Test 13.03.20

Soil properties			Loading		
D_R	[%]	81.3	F_{mean}	[kN]	1.80
σ of D_R	[%]	11.7	F_{cyc}	[kN]	3.85
γ	[kN/m^3]	19.4	w_{cyc}	[mm]	0
γ'	[kN/m^3]	9.4	f	[Hz]	0.10
Installation			f_s	[Hz]	2
F_P	[kN]	69.2	N	[-]	39,980
d_{inst}	[mm]	490	F_{Pc}	[kN]	-4.85
Membrane pressure			w_{Pc}	[mm]	-1.30
p_m	[kPa]	0	v	[mm/s]	0.002

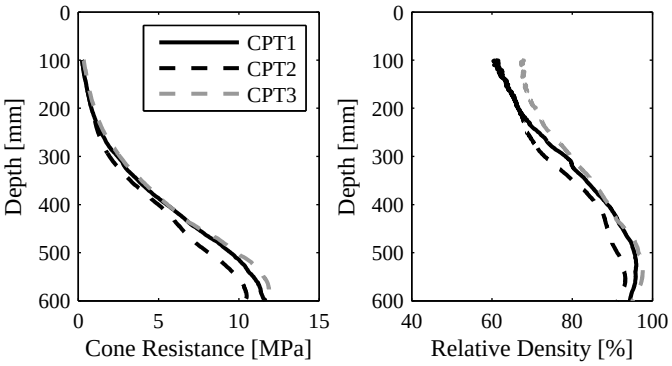

Figure 4.75: CPT testing 13.03.20.

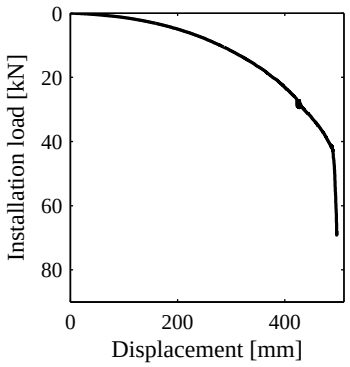

Figure 4.76: Installation 13.03.20.

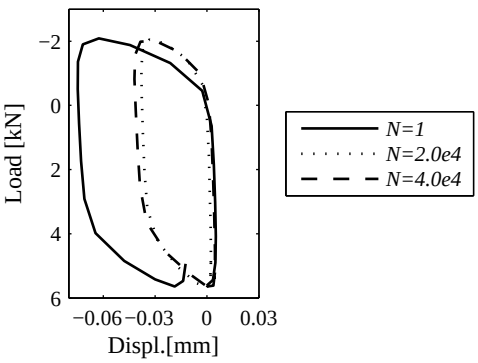

Figure 4.77: Cyclic behaviour 13.03.20.

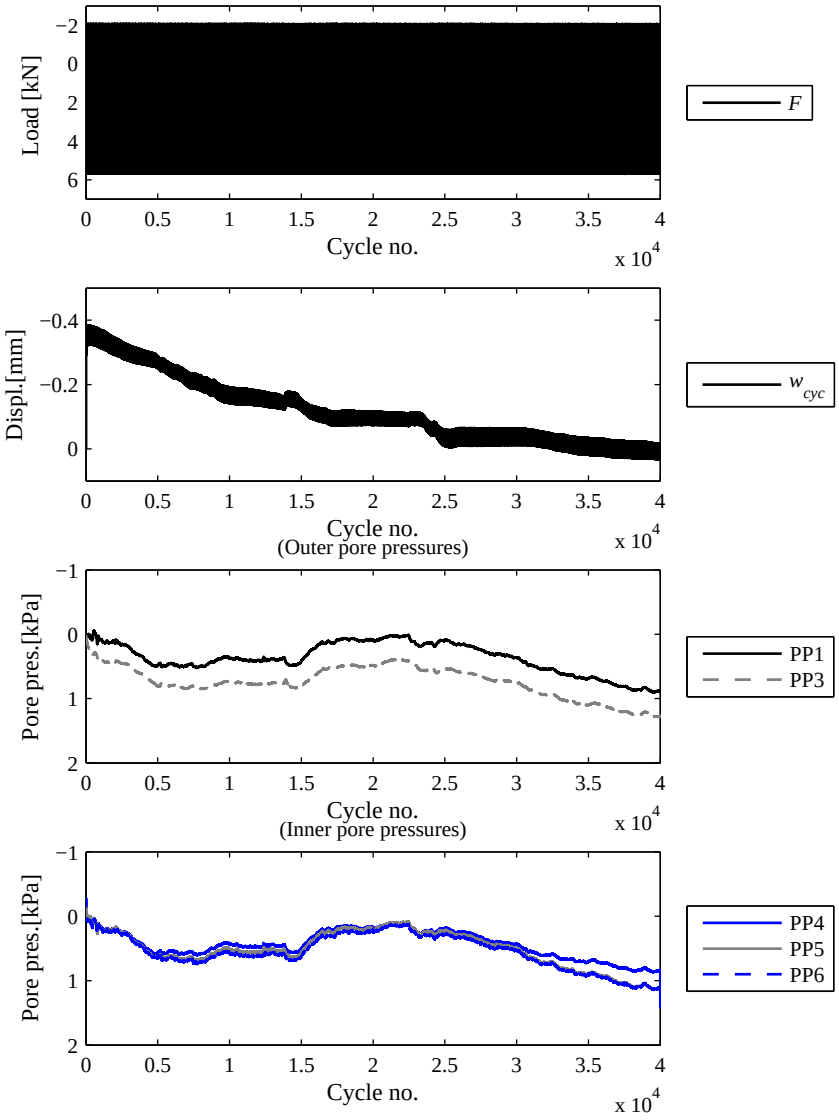

Figure 4.78: Cyclic loading part 13.03.20.

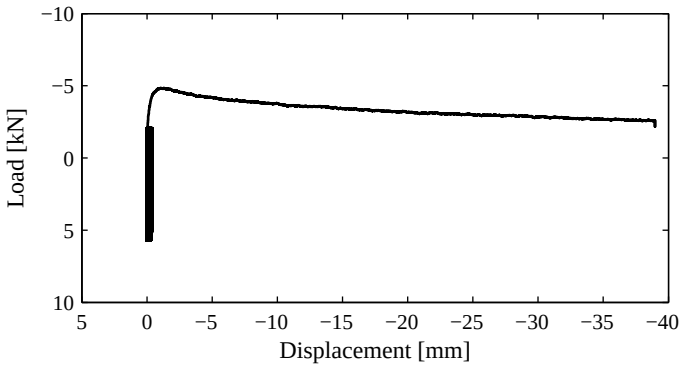

Figure 4.79: Full loading vs. displacement 13.03.20.

Comments:
Sand in the first 0.3-0.4 m was less dense than in the deeper layer. Probably, the soil was strongly disturbed due to another testing program in the same sand box and due to membrane pressure applications that create the upward gradient.

4.18 Test 13.03.21

Soil properties			Loading		
D_R	[%]	80.5	F_{mean}	[kN]	0
σ of D_R	[%]	11.1	F_{cyc}	[kN]	1.00
γ	[kN/m^3]	19.4	w_{cyc}	[mm]	-0.29
γ'	[kN/m^3]	9.4	f	[Hz]	0.10
Installation			f_s	[Hz]	2
F_P	[kN]	(70)	N	[-]	40,020
d_{inst}	[mm]	(490)	F_{Pc}	[kN]	-4.86
Membrane pressure			w_{Pc}	[mm]	-4.84
p_m	[kPa]	0	v	[mm/s]	0.002

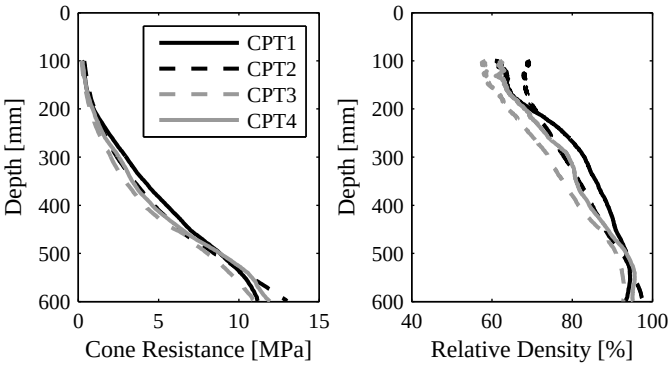

Figure 4.80: CPT testing 13.03.21.

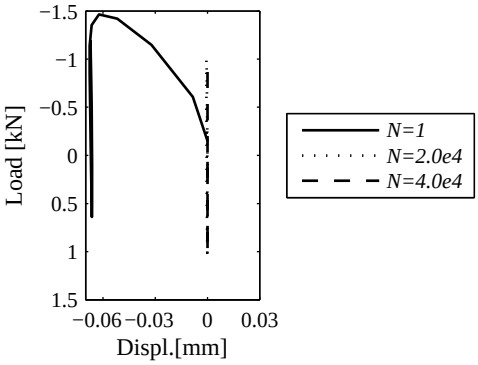

Figure 4.81: Cyclic behaviour 13.03.21.

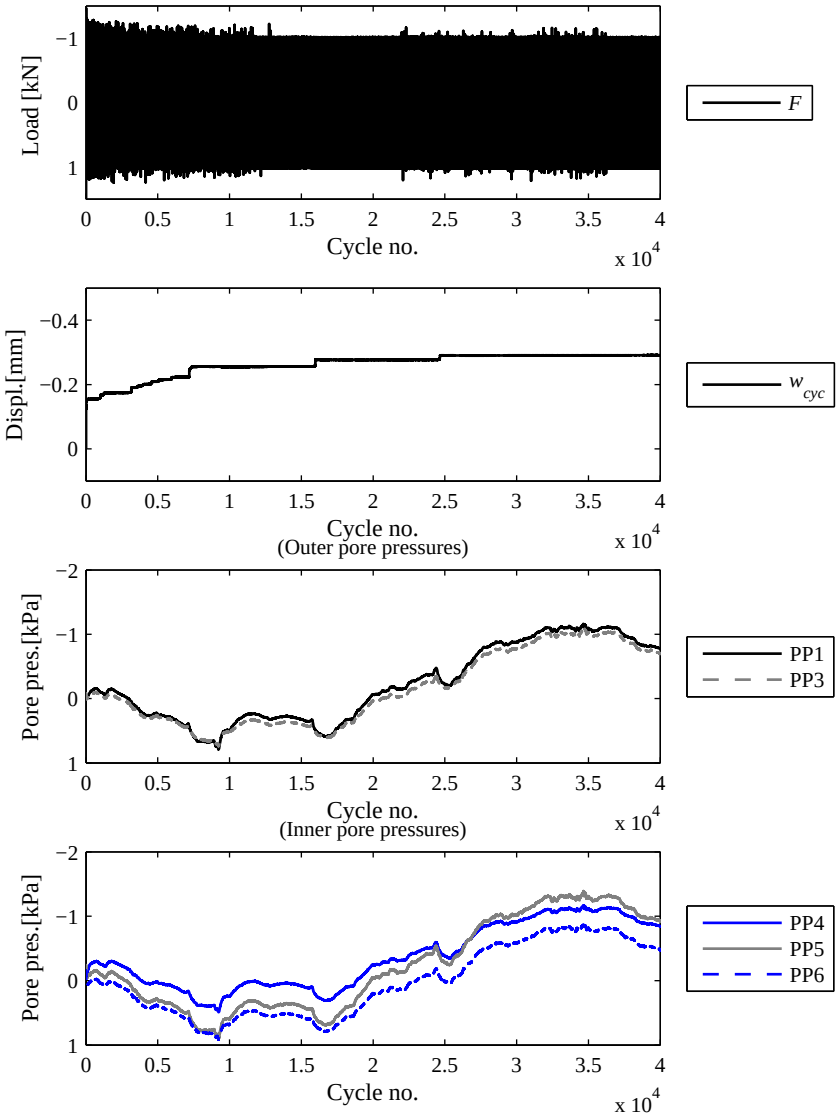

Figure 4.82: Cyclic loading part 13.03.21.

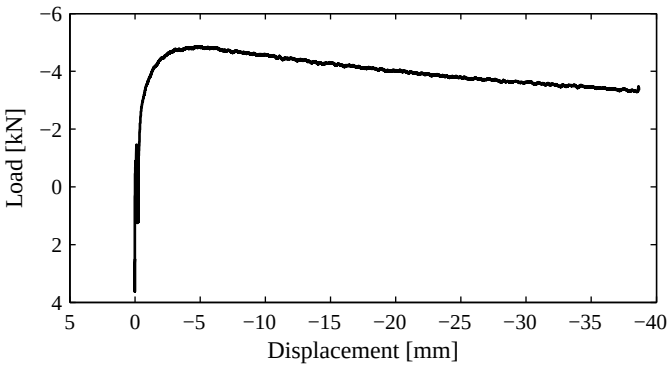

Figure 4.83: Full loading vs. displacement 13.03.21.

Comments:
Sand in the first 0.3-0.4 m was less dense than in the deeper layer. Probably, the soil was strongly disturbed due to another testing program in the same sand box and due to membrane pressure applications that create the upward gradient.

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